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ABSTRACT

To identify and quantify factors which determine the occupational and educational structure of the labor force, the 1960 and 1961 census data of 53 countries were analyzed. Multiple regression analysis showed output per worker and product per capita to be the best explanatory variables for occupational structure. The educational profile of the different occupational categories was correlated with both the educational and occupational structure of the total labor force. The supposedly contradictory manpower and rate of return approaches to the economic objectives of educational planning were reconciled. (BH)

OCCUPATIONAL AND EDUCATIONAL STRUCTURES OF THE LABOUR FORCE AND LEVELS OF ECONOMIC DEVELOPMENT

Possibilities and limitations of an international comparison approach

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OCCUPATIONAL AND EDUCATIONAL STRUCTURES OF THE LABOUR FORCE AND LEVELS OF ECONOMIC DEVELOPMENT

Possibilities and limitations of an international comparison approach

*ORGANISATION FOR ECONOMIC
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PREFACE

This study has been prepared as a sequel to earlier work by OECD on the economic and manpower aspects of education. When, in the beginning of the 1960's, the OECD Directorate for Scientific Affairs came to be heavily engaged in the launching of the economics of education, its work was more particularly concerned with operationalizing the quantitative link between economic growth and educational expansion patterns. One of the more important constraints during those years was the lack of adequate data. As the work of the OECD expanded in scope to include the whole area of educational planning and policy, the emphasis on the economic and manpower dimension became relatively less strong. At the same time more information was becoming available on occupational and educational structures of the labour force in various countries. In spite, therefore, of the widening scope of OECD interests in the educational field, it was nonetheless felt that it would not be inappropriate, after the crude and speculative work of some years ago, to revisit certain aspects of that work now that more data are finally available. It was this consideration that lay behind the decision to undertake the present study. In the final chapter of the main analysis (Chapter XXIV) the relevance of the study is considered in the wider perspective of educational planning and policy.

The source material and data which served as the basis of the present study have been published separately under the title "Statistics of the Occupational and Educational Structure of the Labour Force in 53 Countries" (OECD, Paris, 1969), and the analysis presented here should therefore be considered as a companion volume to this earlier publication.

A first draft of this study was discussed by a group of experts who have been following OECD's work in the field of education since the beginning. Four of them have been good enough to write up their critical observations on the first draft, and these have been included in the present publication.

The study is published in two volumes. The first volume contains the main analysis and the critical comments by Mary Jean Bowman, Mark Blaug, Josef Steindl and Jef Maton. The second volume contains a discussion on classification and aggregation problems, supplementary analyses of the data and a listing of all the observations used in the present analysis (Annexes A to H).

This work was initiated and directed by Louis Emmerij. The bulk of the work has been carried out by Jean-Pierre Jallade, who can be considered as the major author of the study. Claes Croner has made important contributions to Part II of the first volume.

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Part One

GENERAL INTRODUCTION AND PRESENTATION

I

OBJECTIVES AND SCOPE OF THE STUDY

This study aims at elucidating the factors which determine the occupational and educational structure of the labour force. It does so at a rather high level of aggregation, using data drawn from the latest population censuses of up to 45 Member and other countries. It can, therefore, also be considered as bearing on the relevance of international comparisons to the manpower aspects of educational planning. There is no need to set out once more the multiplicity of objectives which the educational system has to serve, and the numerous aspects - social, economic, cultural - which educational planning has to cover. If therefore, the present analysis does not deal with the social objectives of education, curriculum reform, pre-school education, etc., it is not because these aspects are considered as unimportant, but because the study has been focused on another important topic, a topic, moreover, which has been one of the more hotly debated issues in discussions on educational planning.

1. ECONOMIC OBJECTIVES OF EDUCATION

One of the external factors which govern - or should govern - the pattern of educational expansion consists of the requirements of qualified manpower which industrial and technological development imposes upon the educational system. These are the economic objectives of education in the context of the present study. They have quantitative as well as qualitative implications for the educational system. Not only should certain types of personnel be supplied in increasing or decreasing numbers, but their quality should be in line with the changes in the economic and technological environment. This study is concerned with the quantitative aspects only. Moreover, given the scope of the census data, it has only been possible to deal with the formal educational attainments of the labour force, to the exclusion of qualifications obtained through channels other than the formal educational system.

The method which has normally been used to quantify the economic objectives of education is the so-called manpower approach. This approach, at least as it has usually been applied, has been criticized owing, among others, to the wide margins of error which can be expected in the present state of knowledge and techniques. Some authors suggest an alternative method - the so-called rate-of-return approach. *

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* For a critical survey of the various methods and approaches, see C. Arnold Anderson and Mary Jean Bowman, "Theoretical Considerations in Educational Planning", in Educational Planning (D. Adams, ed.), Syracuse University Press, 1964. We will come back to this article in the final Chapter of this study.

It should be noted, however, that this method does not strictly quantify the economic objectives of education. It does, of course, take account of the economic dimension as reflected in relative costs and prices for training the various types of manpower; and it allows one to say, with the usual reservations, whether in the short run one is investing enough, too little or too much in the various types of education. Rather than being competitive, these two approaches should be considered as complementary. *

As is well known, the OECD has done or stimulated, since the beginning of this decade, a certain amount of methodological as well as operational work in the field of the manpower approach to quantify the economic objectives of education (and not in the field of manpower approach to educational planning, as some insist on calling it). This work was mainly carried out in connection, first, with the Mediterranean Regional Project, and, later, with the OECD' s Latin-American Project financed by the Ford Foundation. **

The manpower approach to quantifying the economic objectives of education was first dealt with in a comprehensive manner by H. S. Parnes in his methodological statement, Forecasting Educational Needs for Economic and Social Development. The method was tested empirically in the six country reports of the first stage of the Mediterranean Regional Project. In the light of this experiment, a critical evaluation was made by the OECD of the manpower approach methodology as first conceived by Parnes and others. ***

The rate-of-return approach has crept into the OECD' s work from time to time, but has never succeeded in gaining a firm foothold. **** As its name suggests, this approach consists of quantify the cost and benefit flows of additional years of formal schooling and calculating the rate of return on the investment required for the additional schooling. There are a certain number of conceptual and technical difficulties inherent in this approach. ***** On the other hand, it has the obvious conceptual advantage of trying to introduce cost-benefit analysis, without which most of the projections resulting from the manpower approach are rather devoid of (economic) meaning. These two approaches have been tried out by different people, and this has resulted in a certain number of misunderstandings. In the final chapter of this document, we shall come back to the problem of combining the two approaches. Until then, however, the analyses will focus exclusively on certain aspects of the manpower approach.

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* See, for example, M. Blaug, "Approaches to Educational Planning", Economic Journal, June 1967.

** On the Mediterranean Regional Project, see H. S. Parnes, Forecasting Educational Needs for Economic and Social Development, OECD, 1962; R. Hollister, A Technical Evaluation of the First Phase of the Mediterranean Regional Project, OECD, 1966; see also the six volumes of country reports: Greece, Italy, Spain, Portugal, Turkey and Yugoslavia, OECD, 1965. As regards the OECD's Latin-American Project, see, e.g. Education, Human Resources and Development in Argentina (2 vol.), OECD, 1967.

*** R. Hollister, op. cit.

**** See, for example, The Residual Factor and Economic Growth, OECD, 1964. Also M. Blaug, M.H. Peston, A. Ziderman, "The Utilisation of Qualified Manpower in Industry", in Policy Conference on Highly-Qualified Manpower, OECD, 1967.

***** See, for example, S. Merrett, "The Rate of Return to Education: a critique", Oxford Economic Papers, November 1966.

2. MANPOWER APPROACH AND INTERNATIONAL COMPARISONS

The manpower approach to the quantification of the economic objectives of education starts with projections of output, productivity and employment by sector of economic activity, goes on with the projection of the occupational structure of sector employment, its translation into educational equivalents, and ends by calculating the number of new entrants by level and type of education required for the labour force during the projection period. The methodology used so far, including the OECD one, is a multi-stage approach as opposed to a simultaneous and optimal-solution approach as suggested, for example, by the models of Benard, Adelman and Bowles. *

In this context, the multi-stage approach means that the production function (with the two traditional factors of production, capital and labour) has already been decided upon when the manpower-educational planner comes on the scene. The production function which is being used does not interest us for the moment; it may be the old Cobb-Douglas production function with an elasticity of substitution equal to 1; it may be the Leontief production function with 0 elasticity of substitution, or some kind of a CES production function with an elasticity of substitution equal to n. The important point is that, in one way or another, the amounts of output, capital and labour have been fixed before the manpower planner starts on his work. Those who work with Leontief concepts at this stage are closest to the manpower projection methods as used at present. Indeed, the manpower planner maintains that, once he knows the production function, and thus output, labour and productivity, he will be able to determine the occupational and educational structure of that (already fixed) labour force at the level of technology implicit in the production function. He, therefore, assumed complementarity and technological relationships - a Leontief universe. Clearly, therefore, all the problems around substituting capital for labour, and *vice versa*, are being disposed of during the first stage, and the manpower planner has to accept this as a datum, although he may be able to show later that certain constraints had been overlooked by the economic planners.

But though the manpower approach as currently practised consists of a series of successive approximations, one could very well imagine a simultaneous solution applied to it, as long as one is prepared to draw the theoretical consequences from such a procedure. As mentioned above, this method assumes complementarity between the various aspects of the traditional production function and the types of labour. The procedure of successive approximations is only intended to explore various alternatives and to re-introduce in this way partial substitution possibilities by trial and error. But at its extreme, the method consists in assuming that to each vector of final demand corresponds one, and only one, occupational and educational structure which fulfils the condition of a simultaneous solution.

* Jean Benard, "General Optimization Model for the Economy and Education", in *Mathematical Models in Educational Planning*, OECD, 1967; Samuel S. Bowles, *The Efficient Allocation of Resources in Education: a Planning Model with Applications to Northern Nigeria*, Harvard University, 1965; Irma Adelman, "A Linear Programming Model of Educational Planning: a Case Study of Argentina", in *The Theory and Design of Economic Development* (Irma Adelman and Erik Thorbecke, ed.), Baltimore, 1966.

However this may be, the above discussion clearly points to the importance of examining the values of the occupational and educational input coefficients and their evolution according to the prevailing level of economic and technological development. In the literature on the subject, three basic methods are advocated to project the occupational structure by sector of economic activity: (i) extrapolation of past trends, (ii) international comparisons, and (iii) inter-firm comparisons.* The conversion of the projected occupational structure into educational equivalents is definitely the most difficult step of the manpower approach, and the methods used so far have been a vague mixture of international comparisons, extrapolations and more or less informed guesses.

Given the almost general absence of sufficiently long time-series concerning the occupational and educational structure of the labour force and of detailed data on individual firms, it has been mainly the international comparisons which have served as a guide for estimating the changes in the occupational and educational structures. Information on the international level has also been rare until very recently, and frequently the projections were made by comparisons with one or two other countries only.

It is therefore not difficult to understand that the manpower approach to quantifying the economic objectives of education has been under heavy fire because of alleged unreliable and sometimes even contradictory results.

3. SCOPE OF THE STUDY

In order to get a clearer insight into the usefulness of international comparisons for purposes of manpower projection, a great effort was undertaken to collect data on the occupational and educational structure of the labour force for as many countries as possible.** In this way information was obtained - in more or less detail - for 53 countries drawn from the latest round of Censuses, i.e., for the years 1960 and 1961. The very difficult problems of classification and aggregation which have arisen are dealt with in Annex A. With this amount of information (although, of course, the number of observations varies according to the level of aggregation), it has become possible in principle to test systematically whether there are any significant relationships between the occupational and educational structures of the labour force, on the one hand, and indicators reflecting the level of economic and technological development, on the other.

More generally, an attempt can now be made to examine which factors, including other than economic variables, influence the occupational and educational structure of the labour force. The aim of the present study is, therefore, to identify the factors which govern the evolution of the skill structure of the labour force, and to attempt to quantify the impact of each of those factors. In this way, some light can be thrown on the possibilities and the limitations of an international comparison approach (based on census material) to the economic and manpower aspects of educational planning. Indeed the information available makes it possible to indicate with a certain degree of precision to what extent international comparisons based on census data can be used with a minimum of reliability, and to what extent their use could result in an error. Because of the indiscriminate way in which international comparisons are handled by manpower and educational planners (frequently due to lack of alternative data and/or techniques), the results of this study will be of obvious importance. Because of the mass of various types of data now available from the statistical document mentioned above,* no exhaustive analysis of all the aspects covered by these data has been aimed at. The analysis presented in Parts Two, Three and Four of this Report should be considered rather as a guide to the intelligent use of the data, indicating possible directions for further research as well as those which may prove to be dead ends.

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* See, for example, L. Emmerij and H. Thias, "Projecting Manpower Requirements by Occupation", in Lectures and Methodological Essays on Educational Planning, OECD, 1966.

** This data collection project has been carried out jointly by the OECD's Directorate for Scientific Affairs and the Unit for Economic and Statistical Studies on Higher Education of the London School of Economics. The results are published by the OECD under the title Statistics of the Occupational and Educational Structure of the Labour Force in Fifty-Three Countries, OECD, 1969.

From the above description, it will be clear that the scope of this study, though important, is rather narrowly defined. At the end of it, however, we shall slightly enlarge the subject and touch upon the, to our mind, false dichotomy between the manpower and the rate-of-return approaches to the economic objectives of educational planning.

The structure of the study will be as follows: in the remainder of this first part, we shall present an evaluation of previous work relevant to this study, followed by a general outline of our own analysis.

Part Two will be devoted to the factors which influence the occupational structure of the labour force for the economy as a whole and for the various sectors of industrial activity. Part Three will concentrate on changes in the educational profile of occupational categories, this time for the total labour force only. We shall test systematically relationships between economic and non-economic indicators, on the one hand, and the educational profile of occupations, on the other. Part Four will contain a similar analysis, but this time the educational structure of economic sectors will be related directly to the variables that are supposed to reflect the prevailing levels of economic and technological development. Here the analysis is possible again also in the sector level, avoiding the detour via the occupational structure. The analysis presented in these three parts will be conducted mainly with the aid of regression analysis techniques and by making use of the maximum number of observations available, with the aim of reaching conclusions which can be generalized. Conversely, in Part Five, a certain number of problems which arose in the previous parts will be examined in more depth on a case-study basis, selecting those countries for which more detailed data are available. Finally, Part Six will give the conclusions and re-examine the whole problem of the economic objectives of education in the light of these conclusions.

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* Statistics of the Occupational and Educational Structure, op. cit.

II

EVALUATION OF PREVIOUS WORK

Let us examine several recent publications which concentrate on the manpower link between economic growth and education, more specifically, the studies whose purpose is to test the type of relationships which will be dealt with in Parts Two, Three and Four of this Report.

The publications in question are the following:

1. P. R. G. Layard and J. C. Saigal: "Educational and Occupational Characteristics of Manpower: an International Comparison", British Journal of Industrial Relations, Vol. IV, July 1966.
2. M. A. Horowitz, M. Zymelman, I. L. Herrnstadt, Manpower Requirements for Planning: an International Comparison Approach, Northeastern University, Boston, December 1966 (2 volumes). *
3. The Educational Structure of the Labour Force: a Statistical Analysis, Netherlands Economic Institute, Rotterdam, March 1966 (mimeogr. pub. No. 37/66).
4. J. C. Scoville, The Occupational Structure of Employment, 1960-1980, ILO, Geneva, August 1966 (mimeographed). **

A certain number of preliminary OECD working papers have also dealt with the same subject. They will be mentioned where necessary in the course of this study.

It was considered opportune to look at this subject in the light of production theory, and the first section will, therefore, be devoted to elucidating the type of production function which is explicit or implicit in manpower-educational planning, in general, and in the above studies, in particular. Having set up this overall plan, we shall discuss in subsequent sections, within this framework, the analyses of the occupational and educational structures of the labour force as presented in the publications under review. The way in which problems of aggregation are handled in those documents will be dealt with in Annex A.

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* Mr. Zymelman has produced two other documents using the same data: Productivity, Skills and Education in Manufacturing Industries, UNIDO, May 1967 (restricted), and The Relationship between Productivity and the Formal Education of the Labour Force in Manufacturing Industries, Center for Studies in Education and Development, Harvard University, prepared for UNIDO, November 1967 (Preliminary, mimeographed).

** The original version of this paper was prepared for the "Inter-Regional Seminar in Long-Term Economic Projections for the world economy: Sectoral Aspects". Mr. Scoville kindly sent us the revized version which is the one discussed here.

1. THE PRODUCTION FUNCTION AND MANPOWER FORECASTS

With the exception of the document of the Netherlands Economic Institute, all the other studies mentioned above contain at least a brief reference to production function analysis. Our purpose here is to situate the manpower approach as a special case in the more general context of production studies.

In most studies undertaken on the production function, capital and labour are considered as homogeneous factors of production. Whatever the complexity of more recently developed production functions, * this remains to a large extent true. One can therefore reduce the function to its essential features and write:

$$X = F(K, L) \qquad (1)$$

where X stands for output, K for capital and L for labour

$$X = F(K, L, e) \qquad (2)$$

where e stands for "technical progress" or any other factor (such as education) which is not captured in the quantification of K and L. One might go one step further and distinguish explicitly various types of labour inputs:

$$X = F(K, L_1, L_2, \ldots, L_n) \qquad (3)$$

where L_j (j = 1 .... n) stands for occupational categories. This then is a recognition of the fact that labour is not a homogeneous factor of production, but that it is composed of very different kinds of labour categories. The same reasoning could, of course, be applied to capital. ** Another step would consist in introducing also the educational profiles of each of the occupational categories distinguished:

$$X = F[K, L_1(E_i), L_2(E_i), \ldots L_n(E_i)] \qquad (4)$$

where E_i(i = 1 ..... n) stands for the various levels of educational attainment reached by the members of each of the occupational categories. Equation (4) can, of course, be simplified by writing:

$$X = F(K, E_1, E_2, \ldots\ldots\ldots, E_n) \qquad (5)$$

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* See, for example, Murray Brown, On the Theory and Measurement of Technological Change, Cambridge University Press, 1966.

** See, for example, Ingvar Svennilson, "Economic Growth and Technical Progress. An essay in Sequence Analysis", in the Residual Factor and Economic Growth, OECD, 1964.

where E_i ($i = 1 \ldots\ldots n$) stands for the educational categories into which the labour force can be divided, it being clear that: $E_1 + E_2 + \ldots\ldots\ldots + E_n = L$.

From the point of view of educational planning, the traditional Cobb-Douglas production function, even in its generalized form and even if it includes the residual factor as in (2) above, is not very interesting, although this does not, of course, diminish its importance for production theory in general. This observation also holds for those authors who have tried to introduce explicitly an educational input variable into the production function - in the form of a measure of education per worker. * In the best of cases (the last one), an undifferentiated measure is obtained of the average number of years of education embodied in the labour force. This, no doubt, is important in order to examine the impact of education in general on production, but it is not of much use in defining a strategy for educational development. This, therefore, leaves us with functions (3), (4) and (5) as defined above. Function (3) establishes a link between the occupational structure of the labour force and output, function (5) between the educational structure of the labour force and output, while function (4) constitutes the link between the occupational structure and the educational structure of the labour force on one hand, and output on the other hand. This way of formulating the relationship between production and differentiated factor inputs lays heavy emphasis on substitution possibilities between the various factors of production, including "partial" substitution between the different skill categories.

As already noted in Chapter I, the type of production function underlying most of the work in manpower planning is of the limitational or Leontief type:

$$X = \min. \quad (K, L_1, L_2, \ldots\ldots L_n) \tag{6}$$

or

$$X = \min. \quad (K, E_1, E_2, \ldots\ldots E_n) \tag{7}$$

This is the relationship used in input-output analysis and in most empirical planning work for that matter. It excludes any substitution possibilities and assumes complementary relationships between each of the factors of production, on the one hand, and production, on the other. The technical coefficients through which those complementarity relationships are defined and which are of interest for our purposes can be expressed as follows:

$$X = \min. \quad (L_j) \tag{8}$$

$$X = \min. \quad (L_{jk}) \tag{9}$$

$$X = \min. \quad (L_k) \tag{10}$$

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* See, for example, Zvi Griliches, "Research Expenditures, Education, and the Aggregate Agricultural Production Function", The American Economic Review, December 1964; also M. Brown and A.H. Conrad, "The Influence of Research and Education on CES Production Relations", in Murray Brown (editor), The Theory and Empirical Analysis of Production, Studies in Income and Wealth, Volume 31, NBER, New York, 1967.

We have now introduced the symbols which will be used throughout this Report: $L_j (j = 1 \ldots\ldots n)$ stands for occupational category: $L_k (k = 1 \ldots\ldots n)$, for educational category; and L_{jk}, for the number of persons in occupation j who have attained educational level k.

In the light of these few remarks, let us now turn to the kind of functions used by the authors of the papers under review. Before doing so, it should be made clear that Layard (No. 1) analyses the occupational structure by economic sector, the educational structure by economic sector, and educational profiles, within occupations for the whole economy and the total labour force. Horowitz (No. 2) only deals with the occupational structure by certain economic factors.* The NEI study (No. 3) is concerned with the educational structure of the labour force, and Scoville (No. 4) deals with the occupational structure of the total labour force.

Layard and Horowitz both start from functions (1) and (3) as presented above. They both rewrite equation (3) in the following way:

$$X/L = F\ (K/L,\ L_1/L,\ L_2/L,\ \ldots\ldots,\ L_n/L) \qquad (3a)$$

From here onwards Horowitz simply says**: "if we also assume that K/L is a function of the occupation distribution of L, then it follows that:

$$X/L = F\ (L_1/L,\ L_2/L,\ \ldots\ldots,\ L_n/L)\text{''} \qquad (3b)$$

Layard on the other hand goes on to say:

"The function as expressed in (3) and (3a) does not necessarily imply that there is a unique relationship between output and either the total labour force or its skill composition. The combination of inputs chosen to produce a particular output will depend on their relative prices, and any particular technique will only be chosen by countries having similar relative prices. But once a particular technique has been chosen, this choice will determine simultaneously the level of output per worker (X/L), the amount of capital per worker (K/L), and the proportions of the labour force having each type of skill (L_j/L' s). If we make the further assumption that for any one X/L there is one and only one set of L_j/L' s and one K/L, we can set up demand equations for each of the factors of production, in which L_j/L and K/L are given as functions of X/L rather than the other way round, as in equation (3a). These demand equations are what is needed for purposes of manpower forecasting".***

The meaning of the Horowitz equation could be described as follows. For a given level of productivity, the capital output is fixed and can therefore be dropped from the equation, but there are substitution possibilities between the various occupational categories. This would mean an explicit recognition of the fact that different occupational structures are possible at the same level of output and productivity. The regression equation would give us the "optimal" occupational structure. Layard, however, works with the complementary assumption as soon as the level of technology is fixed. In other words, both Horowitz and Layard agree that substitution possibilities exist at given levels of output; Horowitz goes further and assumes that partial substitution (between skill categories) is still possible at the same level of technology and productivity, whereas Layard assumes that there are fixed skill coefficients once the techniques are chosen and the level of productivity determined.

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* Zymelman 2 (November 1967) deals with the educational structure by certain economic sectors.

** Horowitz, op. cit., p. 32.

*** Layard, op. cit., p. 225.

The two other studies (NEI and Scoville) are implicitly based on the same assumption as that adopted by Layard. Scoville works with the following equation (we have changed his notation to the one used in this report):

$$L_j/L = F \quad (X/P, \ G, \ P) \tag{11}$$

where P stands for total population and G for the growth rate of national income. He also works with what Layard calls "demand equations", and it is again assumed that at a given level of technology there is one and only one occupational structure or, in his own words "... that there should be regular, definable and predictable relationships between the structure of a nation's labour force and the level of per capita income".* Apart from per capita income (X/P), two other factors have been added: the growth rate (G) is supposed to be a proxy variable for a number of growth factors affecting the demand for various occupations, and total population (P) is supposed to reflect economies or dis-economies of scale in the demand for various occupational groups. Whatever the merits or demerits of these explanatory variables, the important point to keep in mind is that only one factor of production is being considered and that therefore, the basic feature of the approach is one of complementarity relationships once the levels of technology and productivity are chosen.

The NEI study adopts the same approach for educational categories and the relationships presented are of the following type (using again our notation)**:

$$L_k/P = F \quad (X/P) \tag{12}$$

*

* *

Of the documents under review, one - through the form chosen for the equation - explicitly allows for partial substitution between the different skill categories of the labour force. The other three studies assume - implicitly or explicitly - that any choice of technology and productivity is linked with one, and only one, particular mix of skill inputs. This has to be kept in mind when considering some of the results at which these studies have arrived.

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* Scoville, op. cit., p. 9.

** For a theoretical discussion on the choice of explanatory variables, see NEI study, op. cit., pp. 23-27.

2. ANALYSIS OF THE OCCUPATIONAL STRUCTURE

As was indicated above, an examination of the relationship between the occupational structure of the labour force and indicators of economic and technological development was carried out by Horowitz, Layard and Scoville.

Horowitz

The following equation was tested:

$$X/L = F\ (L_1/L,\ L_2/L,\ L_3/L,\ L_4/L,\ L_5/L) \qquad (13)$$

Where L_1, L_2 .... L_5 are respectively professional and technical workers; administrators and managers; clerical workers; sales workers; and manual workers. The above relationship was tested for 21 branches of manufacturing as well as for manufacturing as a whole. The maximum number of observations (countries) amounted to 26 - 19 different countries, 7 of which supplied the relevant information for two points in time. In fact, most of the regressions for the manufacturing branches were run with between 13 and 20 observations. This cross-section analysis relied mainly on census data, which means that most figures refer to 1960 or thereabouts, except for the 7 countries that also had this information for a second point in time (around 1950).

The stated objective of the authors is to test the hypothesis that "the productivity of an industry is linked to a specific occupational distribution of its labour force". * In order to do this, they fitted equation (13), with the aid of multiple regression analysis, both in linear and in log-linear form. The results of this regression analysis are quite uneven, not only as far as the multiple coefficients of determination (R^2) are concerned, but also because of the fact that the regression coefficients for certain occupational categories are non-significant and are for that reason not shown in the regression equations presented by Horowitz. In the great majority of cases (i.e., for most manufacturing branches), we are therefore left with two or three occupational categories only. For example, for the total manufacturing sector, when adopting a linear relationship, the regression coefficients of L_1, L_2 and L_4 are significant; in the log-linear relationship, only L_1 and L_2 remain. **

This is not the place to go into a detailed critical evaluation of this document. However, there is one aspect on which it is important to comment, because it is concerned with the problem of partial substitutability versus complementarity discussed previously in this chapter. This aspect is touched upon in the rather surprising "How to do it yourself" Chapter V of the Horowitz document. There, the user of the data, collected by Horowitz, is invited to make projections of the occupational structure of the labour force in the following way. Suppose the economic forecasts for a given economic sector have given a productivity estimate for a future date of $ 1,000, one then looks up in the statistical tables presented in Volume II of the Horowitz document the country (or countries) that has already reached this level of productivity. If, as will happen frequently, one finds two or three countries with about the same productivity level in the selected sector, the user is invited to adopt as occupational structure the average value for each of the occupational categories observed in the reference countries.... This is not necessarily an unrealistic suggestion, but it does not differ from most current practice; moreover, one does not quite see how this recommendation is related to the analysis which preceded it. As already mentioned, Horowitz was the only one to introduce explicitly - through the form chosen for his equation - possibilities of partial substitution. Even if he got a good fit, it would not be possible, therefore, to conclude that there is a unique relationship between skill distribution and the level of productivity, because even if the coefficient of determination is high, this still leaves a large combination of skill percentages which will satisfy the fitted equation for any given productivity level. These partial substitution possibilities are not discussed in the document. It can be expected that these substitution possibilities become more important the more occupations are distinguished. Horowitz, after running his regressions at a very high level of aggregation (and obtaining very heterogeneous results), proposes on the basis of this evidence to deduce a much finer occupational structure (at the 2-digit level) according to the "how to do it yourself" method.

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* Horowitz, op. cit., p. 32.

** Idem, Tables 3 and 4.

Layard

This study, it will be remembered, chose to test a "demand type" equation of the following kind:

$$L_j/L = F \quad (X/L) \tag{14}$$

In this manner each occupational category in turn is made a function of labour productivity (output per worker). The analysis was carried out for the whole economy and in the eight one-digit economic sectors. The occupational categories on which the analysis mainly concentrated were ISCO major groups 0 (professional and technical workers), 1 (managerial workers), 2 (clerical workers), and 3 (sales workers). Combinations of these groups were also tested, such as major groups 0 + 1 and 0 + 1 + 2 + 3 (total non-manual workers). The number of observations was around 20, and the timing of the various variables was again around 1960 for the same reason as mentioned above. The regression equations were tested in log-linear form after finding that this function gave better results than the linear one. The results are again quite uneven. In certain economic sectors (for example, construction and transport), there does not seem to be any close relationship between the size of any of the occupational categories cited above and sectoral labour productivity as measured by the coefficient of determination (R^2). For the whole economy, there is quite a good relationship for major group 0 ($R^2 = 0.83$) with, at the other extreme, a low R^2 for sales workers (0.25). In general, Layard noticed "that the sectors with poorer relationships are also on the whole the smaller sectors."*

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* Layard, op. cit., p. 242.

The conclusions which Layard draws from these results are much more prudent than those advanced by Horowitz, as he lays emphasis mainly on the necessity of additional research.

Scoville

Lastly, Scoville has undertaken an analogous kind of analysis with the aim of "projecting the distribution of employment among jobs of varying levels of social and economic status". It will be recalled that he also worked with a "demand" type equation, but that he identified three explanatory variables which he calls "the economic determinants of the occupational structure". [See equation (11) above.] The analysis was undertaken for the whole economy only and included the nine major groups of the International Standard Classification of Occupations (ISCO).* Given the high level of aggregation, Scoville was able to collect data for about 40 countries. The functions adopted for the regression equation were of the linear and the semi-logarithmic form. The results are summarized as follows.

> "For the set of eight equations (major groups 7/8 and 5 were pooled together) to be used for projection, per capita income is a significant explanatory variable in every case. Rate of growth of national output is significant only in determining the share of sales workers in the labour force, while economies of scale, as indicated by population size, affect the proportion of service and transport-communications workers. The fact that the growth rate and population variables were significant in some of the relationships not chosen for the projections suggests that the question of equation form has not been completely solved."**

The coefficients of determination varied from 0.84 for major group 0 (in semi-logarithmic form) to 0.20 for sales workers using a linear relationship. For Scoville, these results were encouraging enough to go ahead and base the projection of the overall occupational structure (defined according to the nine categories mentioned above) of a certain number of regions on knowledge of the future evolution of his explanatory variables.

3. ANALYSIS OF THE EDUCATIONAL STRUCTURE

Two of the four studies under review have related the educational structure of the labour force directly to indicators of economic and technological development without the detour of passing via the occupational structure - the NEI study and Layard.

NEI

The purpose of the NEI study was (i), to present information on the structure of the labour force according to levels of education for as many countries as possible, and (ii), to undertake some analytical investigations of the statistical material.* The former gives rise to the presentation of the three possible methods in order to cope with the lack of information which is particularly acute when it comes to the educational structure of the labour force. These three methods are (i) the graduate accumulation approach; (ii) the combination method (i.e., estimating the educational structure of the labour force from the occupational structure); and (iii) international comparisons (i.e., estimating the educational structure of country A from the educational structure of country B). The last two methods, in particular, imply quite daring assumptions and should, of course, only be used in the last resort where only very rough data are available. In this sense, the proposed methods are now to a certain extent superseded by the availability of the statistical information published in Statistics of the Occupational and Educational Structure of the Labour Force in Fifty-Three Countries.

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* Major groups 0, 1, 2 and 3 already cited above when discussing Layard's study, plus 4 (farmers, fishermen, etc.); 5 (miners, quarrymen); 6 (workers in transport and communications); 7/8 (craftsmen, production-process workers); and 9 (service, sport and recreation workers).

** Scoville, op. cit., p. 19.

More interesting for our purposes is the regression analysis carried out. It will be recalled that the NEI study fits the following equation:

$$L_k/P = F \quad (X/P) \tag{12}$$

This relationship was tested, in log-linear form, on the level of the whole economy with from 9 to 27 observations, depending upon the educational category. The categories selected were: (i) third-level educated labour force; (ii) idem, but without third-level-educated teaching staff; (iii) scientists and engineers; (iv) physicians; (v) second-level-educated labour force; (vi) idem, but only non-vocational. In general the correlation coefficients are low. However, some of the regression coefficients are rather interesting. For example, the coefficient of elasticity of the third-level educated labour force with respect to output per capita is 1.05; for scientists and engineers, it is 0.95; for the total second-level-educated labour force, it is 0.68, but for those with general secondary education, it amounts to 1.41.**

The study presents an analogous analysis relating the enrolment ratios of the various educational levels and branches to output per capita. Furthermore, on the other sector level, a certain number of tables are presented for six countries showing educational input coefficients as well as the educational structure. Of the four studies under review, this is the only one which introduces, next to the percentage distribution of the labour force, the notion of labour coefficients. Each coefficient indicates the number of people with a certain educational attainment employed in a certain sector for the production by that sector of a million dollars worth of value added. The symbol is:

$$L_{ik}/X_i$$

where i stands for the particular economic sector. No systematic analysis of the changes observed in those coefficients was attempted, however, because of the small number of observations.

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* NEI, op. cit., p. 1.

** This is, however, the category for which only 9 observations were available.

Layard

In this paper, the following educational categories are distinguished: (i) degree level or above; (ii) completed secondary schooling or above; (iii) matriculation level or above; (iv) complete middle level schooling or above; and (v) completed primary schooling or above. Furthermore, a synthetic indicator is proposed for the average number of years of formal schooling embodied in the labour force through a calculation of the median and the mean years of schooling of the labour force in the whole economy and in the various economic sectors selected. The equations tested, again in log-linear form, were of the following type:

$$L_k/L = F \quad (X/L) \tag{15}$$

$$M = F \quad (X/L) \tag{16}$$

where M stands for the mean or median years of formal schooling embodied in the labour force. The number of observations available for the whole economy ranged from 14 to 24 (depending upon the educational category) with a mean of 19. For the individual one-digit economic sectors, the number of observations ranged from 8 to 14 with a mean of 11. The mining sector was excluded for want of data, and electricity was included with manufacturing.

The results are rather erratic; for the economy as a whole, the coefficients of determination are situated between 0.35 and 0.66 (the latter for the category "degree level or above"). The elasticity coefficients of the educational categories with respect to output per worker are all inferior to unity with the exception of "matriculation level or above", for which it is 1.08. In the services sector, the results are rather similar, with the unexpected exception, however, that this time the R^2 for the category "completed primary schooling or above" is the best (0.80); this educational category is also the only one to have an elasticity coefficient larger than unity (1.03). In the construction and transport sector, the fit is almost non-existant. In agriculture, manufacturing (including electricity) and commerce, the fit is somewhat better.

In the light of such limited and erratic evidence, the wisest thing to do is to fall in with the authors in refraining from drawing hard and fast conclusions.

4. ANALYSIS OF THE EDUCATIONAL PROFILE OF OCCUPATIONAL CATEGORIES

Of the authors under review, only Layard examined the educational structure of various occupational categories. He adopted the same educational categories and the same major occupational groups as those mentioned previously in this chapter. The equations were of the same type as those shown above and were again tested in the log-linear form.

$$L_{jk}/L_j = F \quad (X/L) \tag{17}$$

$$M_j = F \quad (X/L) \tag{18}$$

where L_{jk} stands for the number of persons with educational level k in occupation j, and M_j, for the mean or the median years of formal schooling embodied in occupational category j. To give a concrete example: the hypothesis to be tested is that the proportion of persons with, say, a university degree in the occupational category "managerial workers", for example, shows systematic changes relative to the evolution of output per worker. It should be pointed out that this analysis could be carried out on the level of the whole economy only. It would, of course, be highly interesting to study these, or analogous, relationships on the sector level, but for this purpose, three-way tabulations are required: occupations by education and by economic sector. This type of information is rarely available and it is already quite an undertaking assembling a sufficiently interesting number of cross-classifications of occupation/education on the global level. The number of observations available to Layard for this particular part of the analysis ranged between 13 and 24 with a mean of 19. The results of the regression analysis were not exactly inspiring. All coefficients of determination are very low (between 0.01 and 0.40), except for sales workers, for which R^2s of between 0.30 and 0.57 were found .... This last result is all the more surprising as the R^2s for clerical workers are very low indeed - falling between 0.01 and 0.25.

This difference between clerical workers, on the one hand, and sales workers, on the other, is surprising, because it could be expected that it is precisely in those occupational categories with rather "loose" educational requirements that the proposed relationship might have given relatively better results. This would be so because of "educational supply relationships": the higher the level of economic development the more education is normally being made available. It can be assumed that in such circumstances the educational level of the "loose" occupational categories will be upgraded. However, as we have seen, the hypothesis breaks down when applied to Layard's data. The occupational category "clerical workers" is a typical case where the "educational supply effect" can be expected to be important; nevertheless, the correlation coefficients for this group are the lowest of all.

Once more, therefore, the analysis Layard set out to undertake is inconclusive, and he can only point again to the necessity of additional research.

5. CONCLUDING REMARKS

The one important conclusion which can undoubtedly be drawn is that the analyses briefly presented here are all inconclusive. The reasons for this are not hard to find.

There is, first of all, the problem of collecting a sufficient and reliable number of observations. This is a general problem in the four studies under review (less so for Scoville), and it is particularly acute in the case of the NEI study.

Second, there is the question of the variable(s) chosen to reflect overall or sectoral levels of economic and technological development reached. All studies have adopted total or sector labour productivity (or *per capita* income) for that purpose. Only Scoville has added two additional explanatory variables, namely growth rate of GNP and total population, the explanatory power of which were, however, in general very low.

Third, there is the problem of disaggregation. It is probably fair to say that none of the four studies contained a sufficient level of disaggregation, as far as the occupational structure is concerned, to test whether certain more narrowly defined occupational groups had consistently a better or worse correlation with the independent variable(s) than the broad occupational categories.

Fourth, no systematic effort was made to distinguish between satisfactory, less satisfactory and bad relationships. In other words, it would have been interesting to show for which occupations and in what economic sectors the explanatory power of the independent variable(s) was good or bad; and *what the reasons for this could be*. Layard goes a certain way in this direction. At the other extreme, we find Horowitz who draws a general conclusion from very erratic evidence.

This leads us to the more general point of the purposes of those studies. As more or less explicitly set out by the authors themselves, their prime objective was to find relationships which could be instrumental in forecasting the occupational and/or educational structure of the labour force. This may explain why so much confidence was placed in the productivity variable. It remains true, however, that relatively little effort has gone into a careful analysis of why the observed occupational and educational structures are as they are. We are thinking, in particular, of the substitution possibilities mentioned above. It is interesting to note that none of these studies has gone into the problem of whether the same unit of output, *using analogous techniques*, can be produced with different skill mixes. It is therefore, doubtful whether the authors have been able to get the most out of their data.

Moreover, the statistical techniques used are not always explicitly justified; nor is the degree of confidence one can have in the results to meet the authors' objectives clearly spelled out.

We shall now give an outline of the rationale of our own analysis, and intend then to come back to some of the points raised here.

III

GENERAL PRESENTATION OF THE STUDY

The bulk of the analysis undertaken in the present study is devoted to an attempt to explain changes in the occupational and educational structures of the labour force as observed in the various countries under review.* In trying to explain the observed situation, explanatory variables which are themselves extremely difficult, if not impossible, to forecast, have frequently been brought in. A distinction should, therefore, be made between the attempt to explain the observed situation, and the usefulness of the relationships established for forecasting purposes.

Here we shall, first, present the types of relationship selected for this study; we shall then proceed to discuss in general terms some difficulties of a theoretical and statistical nature inherent in investigations of this kind.

1. TYPES OF RELATIONSHIP EXAMINED

We shall deal successively with the occupational structure, the educational profile of occupational categories and, lastly, the educational structure of the labour force.

i) The occupational structure

In the first instance, the type of relationship examined is of the following general form:

$$Lj/L = F \quad (n) \tag{3.1}$$

The dependent variable is, therefore, the percentage of a given occupation j in the whole economy or in a sector of economic activity; n stands for any of the explanatory variables selected to reflect levels of economic and technological development, again both on the level of the economy as a whole and of the sector. In the following parts of this study, this variable n will take the form of output per worker (X/L), of gross capital formation per worker $(\Sigma I/L)$, of a non-monetary indicator of the level of economic development (In), of energy consumption per worker (En/L), etc. More specific sector indicators, such as the number of tractors in use in agriculture, will also be introduced when it is felt that a more thorough analysis in certain economic sectors is called for. The variable n should reflect as much as possible the different factors that determine the economic and technological "requirements" for the various occupational categories.

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* For a listing of the countries used in the different parts of the analysis, see Appendix 1.

Next to the occupational percentage distribution, an attempt is also made to analyse the different values observed in the occupational coefficients: Lj/X instead of Lj/L. The rationale of this approach will be set out later in this study.

ii) Occupation/Education Relationships

A pattern of analysis analogous to the one outlined above has also been adopted for the investigation of the differences observed in the educational profiles of occupational categories. The first general type of relationship tested is:

$$Ljk/Lj = F\ (n) \tag{3.2}$$

The number of persons with an educational level k in occupation j, expressed as a percentage of the total number of persons in occupation j, is made a function of the same kind of explanatory variables as mentioned above. The second type of relationship examined is:

$$Ljk/L = F\ (n) \tag{3.3}$$

This time, the number of persons with educational level k in occupation j is expressed as a proportion of the total labour force. The first relationship (3.2) follows the so-called manpower approach, which - in its methodological chain - first, forecasts the occupational structure and, then, translates each of the occupational categories into educational equivalents. The second (3.3) can best be considered as a "weighted" occupational category. This less sensitive ratio (as compared to Ljk/Lj), while giving the same information as (3.2), will also serve to test the hypothesis that when only certain educational categories within the occupational groups are taken into account, measurement errors will tend to diminish and the chance of obtaining better relationships will consequently improve.

Next to the above types of "demand" equations, an attempt will also be made to examine whether the educational supply pattern can, to any extent, add to the explanation of the observed differences in educational profiles of the occupational categories. This is done by introducing the total stock of people in the labour force with a level education (k) which normally corresponds to the occupational category in question. This variable (Lk/L) will be examined alone and in combination with the economic and technological indicators (n):

$$\left.\begin{array}{l} Ljk/Lj \\ \text{or} \\ Ljk/L \end{array}\right\} = F\ (Lk/L) \tag{3.4}$$

$$\text{or} \quad \left.\begin{array}{l} Ljk/Lj \\ \\ Ljk/L \end{array}\right\} = F\,(n,\ Lk/L) \qquad (3.5)$$

Much more detailed information about the rationale of the above approach will be given in Part Three of this study.

Analysis of the occupation/education relationships is possible at the level of the whole economy only, although in Part Five we shall attempt to go into more depth on a case-study basis.

iii) The Educational Structure

The educational structure of the labour force will be related directly to a certain number of economic and technological indicators through the following equation:

$$Lk/L = F \quad (n) \qquad (3.6)$$

In the light of the description given above, these relationships do not need further explanation. This analysis will be feasible for the whole economy and for certain economic sectors.

* * *

In terms of the theoretical framework set up in the beginning of Chapter II, it will be clear that the present analysis starts from the basic assumption of fixed occupational and educational coefficients at given levels of economic and technological development. We want to stress, however, that it is precisely one of the main aims of this study to verify the validity of this assumption. In order to do so, graphic analysis of the above types of relationship - together, of course, with an examination of the correlation coefficients and, particularly, of the standard deviations of the regression coefficients - will prove to be useful, because it will allow us to see whether there exists an important spread of the occupational and educational coefficients at analogous levels of development. Whenever the latter is the case, this may suggest the existence of substitution possibilities.

2. REMINDER OF SOME DIFFICULTIES

There are a certain number of theoretical and statistical problems which, though well known, are worth recalling before we enter into the analysis of the available data. These remarks apply both to the studies reviewed in Chapter II and to our own analysis.

i) The Identification Problem

During a conference on the theory of production, one of the participants said in despair to the organisers: "You should go into a respectable field, like astrology". * Many problems with which manpower planning analysts have to cope reflect to a large extent the state of production theory in general. Although there is no need to be defensive about the kind of relationships exposed above, one should recognize that they are largely *ad hoc* relationships.

As has already been stressed in other OECD documents, ** the evolution of the educational stock in the labour force is the result of the interaction of demand and supply effects and a basic weakness of the usual manpower planning methodology is its focus on what might be called the demand effects to the exclusion of the supply effects. None of the studies reviewed in Chapter II - with the exception of the NEI publication - have mentioned explicitly this simultaneity problem, nor have they taken care to point out in the analysis that their single equation relationships may implicitly be reduced forms of more general simultaneous relationships (and therefore face the problem of inference from the coefficients of the reduced form to the coefficients of the structural equation they implicitly seek, i.e., the problem of identification).

It is the awareness of this identification problem that has led us to introduce equations (3.4) and (3.5) above. Quite clearly, these are also *ad hoc* relationships but, faced with an admitted inability up to now to derive from the theory an adequate specification of the set of structural equations, all one can do in the process of the analysis is to ask the question: is the proposed relationship a demand function, a supply function, a reduced form, or a mixture of all those ?

ii) *Statistical Techniques*

The investigations carried out in Parts Two, Three and Four make extensive use of simple and multiple regression analysis techniques. These techniques are particularly appropriate to shed light on our problem, which is to test whether significant and systematic relationships hold between changes in the occupational and educational structures of the labour force, on the one hand, and changes in the level of economic and social development, on the other.

The form of the regression equation will be the double logarithmic (or log-linear) one. This decision was taken after the examination of a considerable number of graphic representations and also after experiments with a number of other functions. Some of these will be presented in Part Two. The double-log form finally retained implies, of course, constant coefficients of elasticity which, when used over long time periods, pose problems of consistency. It should, therefore, be kept in mind that the regression (elasticity) coefficients presented in this study are valid only between the extreme limits of the values of the explanatory variables; beyond those values, great care is required in their interpretation.

As the title of the present study indicates, the analysis will be undertaken on a cross-section basis. In those cases where the results of the calculations seem to be useful for forecasting purposes, we are thrown right back to the controversy about the validity of cross-section estimates in time-series applications. This problem is far from being new and the international literature has devoted a good deal of attention to it.* The results of these comparisons are always the same: the parameters in the case of time-series analysis are different, and often substantially so, from those which use cross-section material. One of the reasons for this difference is undoubtedly that the application of the method of least squares is frequently pure convention and without theoretical foundation. It is well known that two of the conditions for the method of least squares to result in an estimate of the greatest likelihood are that random deviations be independent and that their distribution be normal. The first condition is rarely fulfilled in time-series analysis: deviations in economic time-series are not independent, as a rule. The second condition is rarely fulfilled when using cross-section material with countries as the unit of observation; it does, however, allow us to escape much more from the problem of collinearity which obscures time-series relationships.

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* See Murray Brown (ed.), *The Theory and Empirical Analysis of Production*, New York, 1967, p. 8.

** For example, A Technical Evaluation, *op. cit.*

The conclusion must be that, in the absence of a sufficient number of time-series, the results presented in the following pages should be regarded, first of all, as an elucidation of the observed situation. The parameters must not be used mechanically for forecasting purposes within a given country. The specific situation of the country will have to be carefully evaluated. The parameters determined with the aid of international evidence will be only one of the elements to be used in such an evaluation.

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* The well-known article by H.G. Chenery, "Patterns of industrial growth", AER, September 1960, for example, was based on cross-section evidence. The parameters determined in this way have been much criticised when compared with time-series evidence; see, M.D. Steuer and C. Voivodas, "Import Substitution and Chenery's Patterns of Industrial Growth", Economie internationale, February 1965. Many other examples can be found in Murray Brown (ed.), The Theory and Empirical Analysis of Production, op. cit.

Part Two

OCCUPATIONAL STRUCTURES AND ECONOMIC DEVELOPMENT

In this Part, attention will be focused mainly on the relationship (3.1): $Lj/L = F(n)$. This relationship has been tested for the whole economy, for the eight one-digit sectors of economic activity, and for certain manufacturing branches (at the two-digit level of ISIC). The unit of observation is the country: in other words, the occupational categories will be analysed for one economic sector at a time across the countries for which observations on Lj and n are available.

The presentation of the analysis will be as follows. In Chapter IV, the dependent and independent variables used in the analysis will be presented. Chapter V will be concerned with the results of the simple regression analysis, which will represent the bulk of this Part of the study. Chapter VI will deal with a series of supplementary calculations, such as multiple regression analyses, the correction for "deviant cases", functions with variable elasticity, etc., and Chapter VII will draw the conclusions from the analysis.

IV

PRESENTATION OF THE VARIABLES

The dependent variables (occupational categories - the Lj's) which will be used throughout the following analysis are*: 0, professional and technical workers; 1, executive and managerial personnel; 2, clerical workers; 3, sales workers; 0-0, engineers, architects and surveyors; 0-1, chemists, physicists, etc.; 0-2, agronomists, biologists; 0-X, draughtsmen, and science and engineering technicians; 1-1, directors, managers and working proprietors; 0-02, engineers alone.

Moreover, at the level of the major occupational groups, 0 + 1 together have also been tested, called here the HLM (high-level manpower) category, as well as 0 + 1 + 2 + 3 (the "non-manual workers). At the level of the minor groups, 0-0, 0-1, 0-2 and 0-X have been grouped into an STP (scientific and technical personnel) category. The above categories have been analysed in all the economic sectors under review. On certain occasions, other occupational groups will make an appearance; these will be explained at the appropriate moment.

The different explanatory variables (n) which have been used most of the time throughout the economic sectors are: output per worker (X/L for the whole economy; Xi/Li for the various sectors of economic activity) or GDP *per capita* (X/P) for services; a "non-monetary" indicator of development (In); ** energy consumption *per capita* (En/P); gross capital formation per worker over a period of seven to eight years preceding the census year (ΣIL/); and the sector share of employment in the various economic sectors (Li/L). Let us comment on each of these variables.

The reason for selecting a series of variables stems from our main concern to find an appropriate indicator of technology, i.e., one reflecting the economic result of a state of knowledge as embodied in the factors of production and their combination. The traditional indicator adopted in the so-called manpower approach and in previous studies of

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* The codes preceding the occupational categories refer to those used for the major groups, the minor groups and the unit groups in *ISCO* - International Standard Classification of Occupations, ILO, Geneva, 1958. In the following pages, we shall sometimes only refer to these codes, without always repeating the full name of the occupational category.

** The index used here is the one published by D.H. Niewiaroski, "The Level of Living of Nations: Meaning and Measurement", in *Estadistica*, Interamerican Statistical Institute, Washington, March 1965. For a critical review, see W. Beckerman, *International Comparisons of Real Incomes*, OECD, 1966, p. 22.

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this kind (see Chapter II) has been output per man and per year (X/L). Clearly, this is but a convenient short form of a complex indicator reflecting the contribution to production of all factors of production. The denominator L is not measured with any precision, since it neglects inter-country differences in hours worked. As to the numerator, available national account statistics* do not always give standardized data. Thus, for countries like Israel, South Africa, Syria, Japan and Chile, only *net* value added figures are given: for the socialist countries, net material product is of course presented. Multiple adjustments have thus been made, the details of which appear in the tables in the Annex to this volume. A serious and usual difficulty with this indicator is the exchange rate problem. All production data have been converted into United States dollars by using the *official exchange* rate for the year in question.

This straightforward "solution" was preferred to experimenting with parity rates, for example. We turned in another direction by searching for (i) a composite index reflecting the different productive activities of each country weighted in physical terms (primarily in view of the analysis at the level of the whole economy), and (ii) more sector-specific physical indicators. Non-monetary indicators of the first type are, of course, hard to find, particularly in the light of the large number of countries covered by our analysis. At least two of these indicators, however, are available: they can be found in the already quoted publications by D.H. Niewiaroski and W. Beckerman, respectively. In this study, we have used primarily the first one (In).

Niewiaroski actually constructed three indices: one based on predominently economic variables; a second referred to as the "social" index, and a combination of the two. The object of this approach is to avoid the purchasing power problem, and its fundamental postulate is that well-being is reflected by certain key items in a nation's economy: "By selecting appropriate items and giving them suitable weights, an index can be constructed that provides a direct measure of well-being. Since the items chosen are expressed in physical quantities rather than money values, conversion at dubious exchange rates is unnecessary, and the troublesome purchasing power problem is avoided". The basic items selected by Niewiaroski for the construction of the economic index are the following: (i) the proportion of the labour force engaged in non-agricultural activities; (ii) number of telephones *per capita*; (iii) energy consumption *per capita*; (iv) steel consumption *per capita*; (v) cement production *per capita*; (vi) motor vehicles *per capita*; (vii) *per capita* fibre consumption; (viii) proportion of protein in diet, and (ix) the (dollar) value on exports *per capita*.

The "social" index includes selected items of social services, information flows and school standards. It will be briefly described with regard to the analysis of the occupational structure of services for which it has been used.

It is of obvious interest to include these non-monetary indicators in the analysis in order to examine how their influence compares with that of the productivity variable (X/L), not only because of the distorting role played by the exchange rate problem, but also because In may be a more comprehensive synthetic measure of the level of economic and technological development. Clearly, for forecasting purposes the In is useless, and from that point of view one can, therefore, only hope that X/L will turn out to be at least as important as explanatory variable as In.

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* Our principal source has been the successive UN Yearbooks of National Accounts (1961-1965). Where differences showed up from one edition to another, the 1965 edition was used.

As pointed out above, a number of other non-monetary indicators of technological or economic development have been utilized in the global or sector analyses. Some of them are, in fact, component parts of the non-monetary indicator just mentioned. The global energy consumption (converted into kg. of coal equivalent)* per capita (En/P) is frequently used to represent technology. In so far as it relates the use of all sources of energy to the total population it also gives an idea of the general level of living (as symbolized by the used of electric light, heating, public transport, etc.).

Ideally, we would also have liked to introduce the capital stock as one of the explanatory variables. As can easily be understood, reliable figures on the capital stock for 40 to 50 countries are impossible to find, especially by sector of economic activity. We decided, therefore, to take as a proxy variable the sum of gross capital formation covering the seven years preceding the census year ($\Sigma I/L$). The period of seven years is of course a rather arbitrary choice, but it is sufficiently long to cancel out cyclical movements and represents, moreover, an absolute amount important enough to have repercussions on the occupational and educational structures of the labour force.

A variable reflecting the sectoral distribution of the labour force (Li/L) has also been included in the analysis, primarily as a scale indicator of the respective economic sectors.

Lastly, a certain number of more sector specific, physical indicators of technology were selected, such as fertilizer consumption, tractors per worker (in agriculture), cement production per capita (construction), commercial vehicles per worker (transport), etc. The reason for including such types of variables is the same as that given for En/P above. **

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* See World Energy Supplies, UNO, 1959-1962, for the conversion key applied, p. 67.

** The listing of observations used, both for the dependent as well as for the independent variables, can be found in Annex F.

V

RESULTS OF THE SIMPLE REGRESSION ANALYSIS

The equation which is being used at this stage of the analysis is of the following general form:

$$\log (Lj/L) = \log a + b \log (n) \qquad (6.1)$$

or

$$\log (Lij/Li) = \log a + b \log (n) \qquad (6.2)$$

where i stands for the eight main sectors of economic activity as indicated in Tables II-2 to II-9 respectively [equation (6.1) refers to the whole economy, see Table II-1]; j stands successively for the occupational categories enumerated in Chapter IV above and which can be found at the left-hand column of the tables; and n for the various explanatory variables X/L, In, En/P, ΣI/L, etc. The explanatory variables have also been presented above and can be found horizontally in the top row of the tables. All tables are presented in a standard manner and indicate each time the number of observations (N), the correlation coefficient (R), the constant (log a), and the regression coefficient (b) with its standard deviation (σb) in brackets.

We shall deal successively with: the whole economy; manufacturing; services; agriculture; mining; construction; electricity, gas and water; transport and communications; and commerce.

1. THE WHOLE ECONOMY

Table II-1 presents the results of the simple regression analyses. Looking, first, at the correlation coefficients (R), it is clear that the best overall results are obtained with the productivity variable (X/L), although the Rs obtained with the other explanatory variables (In, En/P and ΣI/L) are quite respectable. Thus, the correlation coefficients between occupation categories and X/L on the one hand, and In on the other, can be considered for all intents and purposes as equal. It may, therefore, be concluded (also in the light of the b coefficients and their standard deviations) that avoiding the exchange rate and purchasing power problem through the introduction of a non-monetary index of development has not resulted in a better fit and additional explanatory power. This is important for those interested, above all, in manpower forecasting; although the future development of labour productivity is

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Table II-1. WHOLE ECONOMY: SIMPLE REGRESSION EQUATIONS BETWEEN OCCUPATIONAL STRUCTURE (Lj/L) AND ECONOMIC INDICATORS (n)

$$\log (L_j/L) = \log a + b \log (n)$$

	OUTPUT PER WORKER: X/L				NON-MONETARY INDEX: Ie				GROSS CAPITAL FORM. PER WORKER: Σ I/L				ENERGY CONSUMPTION PER CAPITA: E/P			
	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)
Major Groups:																
0	43	0.91*	-1.37	0.66(0.05)	43	0.89*	-0.56	0.84(0.07)	28	0.92*	-0.88	0.51(0.04)	42	0.86*	-0.42	0.38(0.04)
1	42	0.83*	-2.68	0.92(0.10)	42	0.76*	-1.44	1.09(0.15)	27	0.74*	-1.65	0.60(0.11)	41	0.78*	-1.32	0.52(0.07)
0+1	42	0.93*	-1.46	0.73(0.05)	42	0.88*	-0.53	0.90(0.08)	27	0.93*	-0.83	0.54(0.04)	42	0.85*	-0.36	0.41(0.04)
2	42	0.82*	-1.49	0.71(0.08)	42	0.85*	-0.71	0.96(0.09)	27	0.75*	-0.61	0.44(0.08)	41	0.81*	-0.54	0.44(0.05)
3	42	0.20	0.37	0.14(0.11)	42	0.23	0.49	0.22(0.15)	27	0.32			41	0.09		
0+1+2+3	42	0.79*	-0.22	0.48(0.06)	42	0.79*	0.36	0.62(0.09)	27	0.83*	0.15	0.37(0.05)	41	0.71*	0.51	0.27(0.04)
Minor Groups:																
0-0	24	0.87*	-3.74	1.06(0.13)	24	0.82*	-2.36	1.29(0.19)	15	0.70*	-2.78	0.78(0.22)	23	0.87*	-2.36	0.66(0.08)
0-1	22	0.79*	-5.23	1.21(0.21)	22	0.70*	-3.50	1.36(0.31)	15	0.62*	-3.49	0.67(0.24)	22	0.81*	-3.93	0.83(0.13)
0-2	26	0.53*	-4.01	0.89(0.29)	26	0.52*	-2.93	1.14(0.39)					25	0.48*	-2.40	0.42(0.16)
0-X	23	0.53*	-2.31	0.64(0.22)	23	0.60*	-1.79	0.98(0.29)	15	0.63*	-2.56	0.73(0.26)	22	0.74*	-1.91	0.55(0.11)
0-0+0-X	31	0.77*	-3.41	1.06(0.16)	31	0.81*	-2.29	1.46(0.20)	19	0.78*	-3.24	1.00(0.19)	30	0.85*	-2.19	0.72(0.08)
STP	31	0.79*	-3.05	0.98(0.14)	31	0.82*	-2.00	1.33(0.18)	15	0.76*	-2.61	0.84(0.18)	30	0.86*	-1.90	0.66(0.07)
0-02	16	0.92*	-3.99	1.10(0.12)	16	0.90*	-2.83	1.51(0.20)	10	0.90*	-3.30	0.89(0.16)	15	0.95*	-2.77	0.75(0.06)
1-1	25	0.73*	-2.82	0.92(0.18)	25	0.66*	-1.46	1.04(0.25)	17	0.62*	-1.67	0.57(0.19)	24	0.68*	-1.42	0.52(0.12)

NOTE: In this table as well as in the following tables of this study, an asterisk * means that the correlation coefficient R is significative at the 5 per cent confidence level.

not easy to predict, In is, of course, almost impossible to forecast. Attention must also be drawn to the excellent performance of the energy variable (En/P) with respect to the minor groups and, in particular, to the STP category. It also becomes clear that sales workers (m. g. 3) are in no way related to any of the explanatory variables selected. This problem will be taken up again in the next section where a possible explanation of this "outstanding" result will be advanced. Interestingly enough, the R's for the minor group 0-0 and for the even more narrowly defined unit group 0-02 (engineers) are also quite high: 0. 87 and 0. 85, respectively, with X/L; 0. 87 in both cases with En/P. The STP group as a whole has a correlation coefficient between 0. 79 and 0. 86 with X/L and En/P respectively, which is not unsatisfactory. It has to be borne in mind, however, that the number of observations available for the minors occupational groups is less than for the major groups.

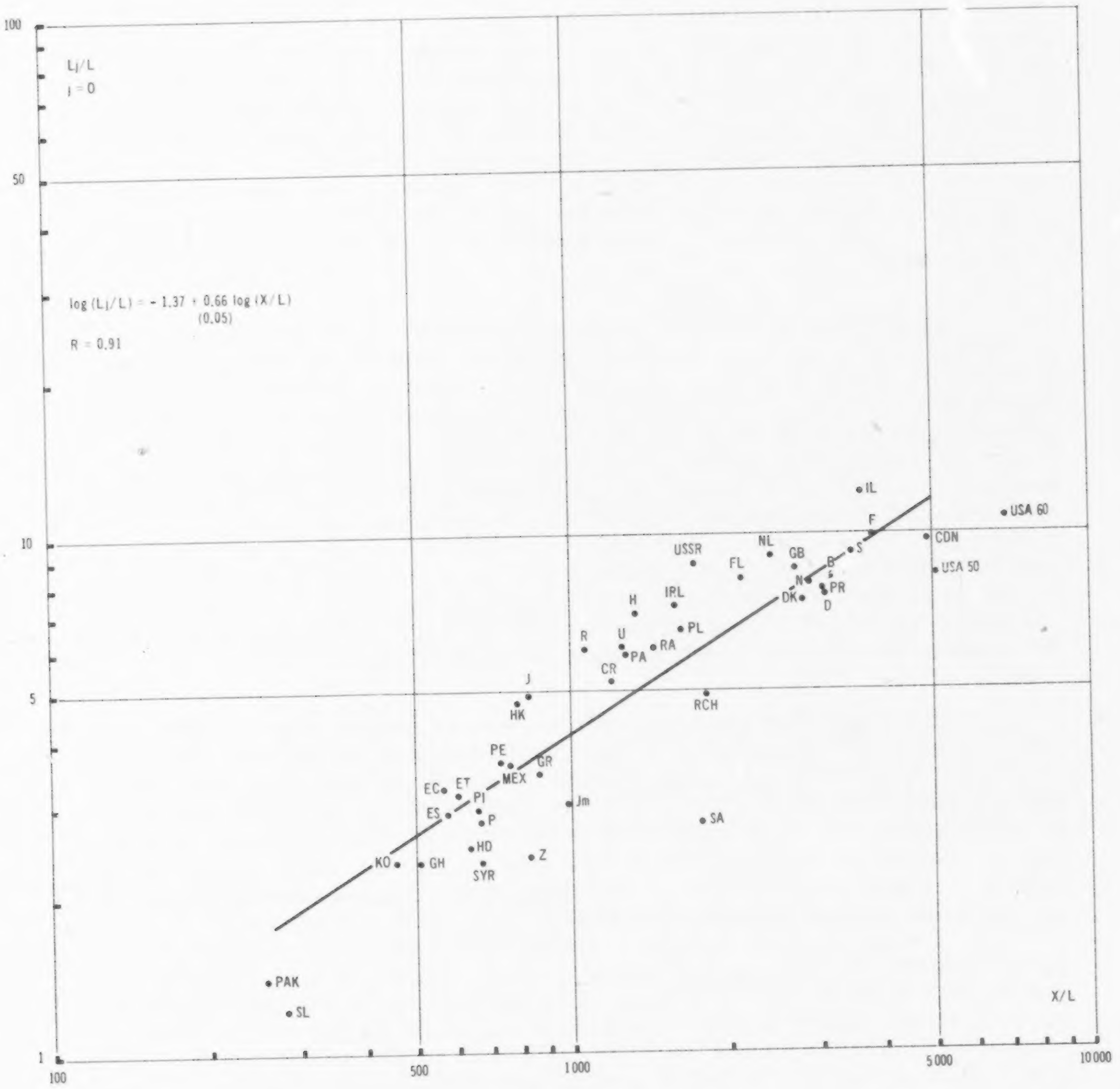
A comparison of the R's for the various minor groups shows that the technician's category (0-X) is, together with minor group 0-2, systematically at the bottom of the list as far as the results of the calculations are concerned. It could be expected a priori that for this heterogeneous category the danger of errors of definition and classification might be particularly great, especially as definitions may vary from country to country. It is for this reason that we have included the special occupational category 0-0 + 0-X, i. e. engineering personnel together with technicians. The results, when combining these two categories, show an important improvement as compared to 0-X alone, and in one case even as compared to 0-0 alone (i. e., with $\Sigma I/L$ as the explanatory variable). This tends to confirm the hypothesis regarding the distorting effect of the classification and definition problem.

For the problems under examination in this Part of the study, the regression coefficients (the b's) and their standard deviations are more important than the correlation coefficients. Given the log-linear function adopted, these b's are of course readily interpretable elasticity coefficients of the Lj/L's with respect to the different explanatory variables. Starting again with the major groups, the striking aspect is the higher b-coefficient for the managerial group (m. g. 1) as compared to all the other major groups. In other words, with rising levels of development, the managerial category would have a tendency to increase relatively faster than the other major groups, including the professional and technical workers. A glance at Graph II-2 could suggest that this high elasticity might be due to a few "suspicious" countries. This problem of "deviant cases" will be dealt with in the next chapter. All the b coefficients of the major groups are statistically significant (in many cases, the standard deviations are even quite small), except the one for sales workers (m. g. 3), which decidedly is our "bête noire".

An examination of the b coefficients of the minor groups indicates that, on the whole, the STP categories have higher elasticities than the major groups, including the managers and a fortiori the entire professional and technical personnel category of which those STP occupations are a part. This is, in particular, the case for the engineering categories (0-0 and 0-02) and for the combined engineers and technicians group (0-0 + 0-X). This evidence would thus apparently lend support to the often proclaimed hypothesis that the scientific and technical personnel has to grow faster than the other HLM categories, and also faster

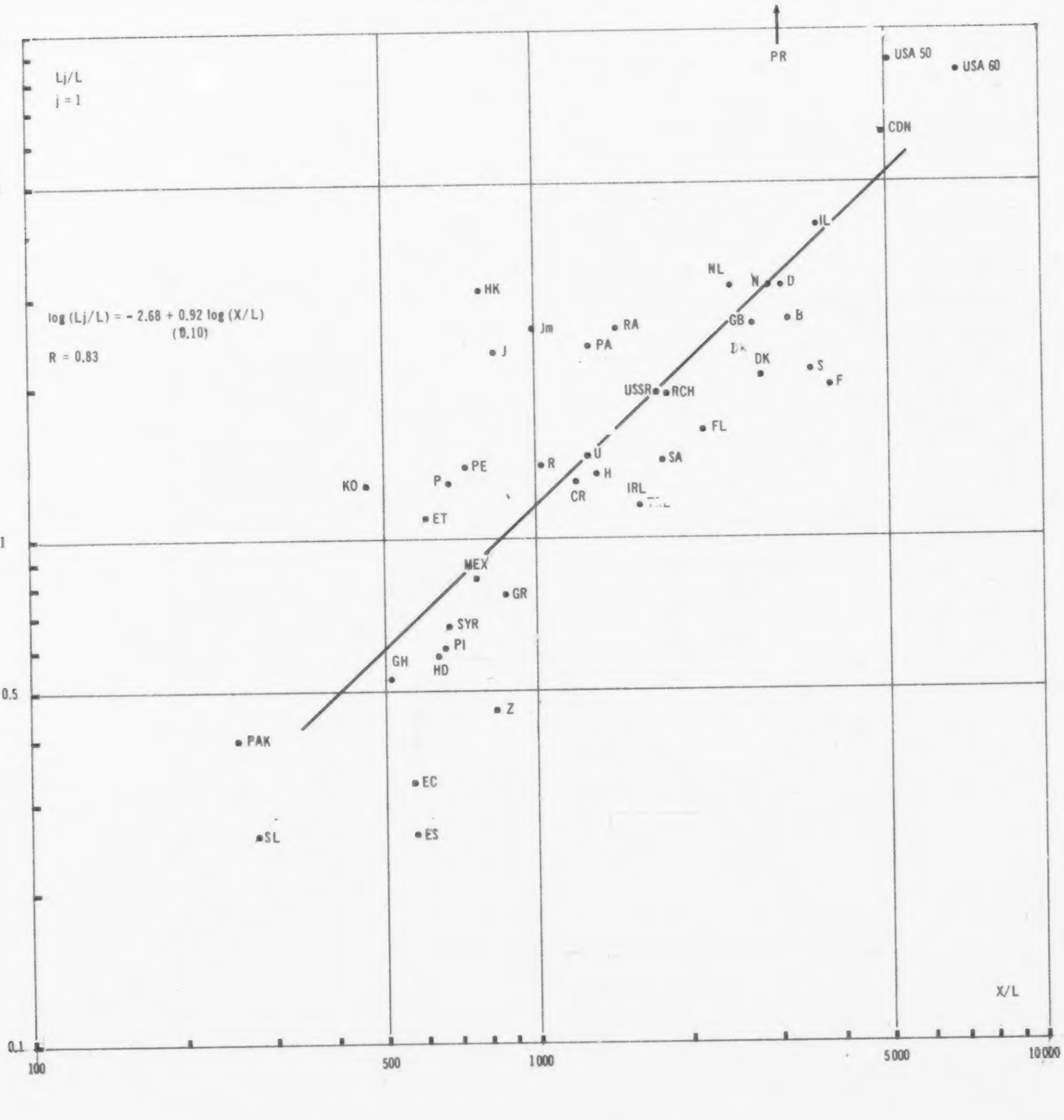
Graph II-1

WHOLE ECONOMY: PROFESSIONAL AND TECHNICAL WORKERS (Lj/L) AND OUTPUT PER WORKER (X/L)



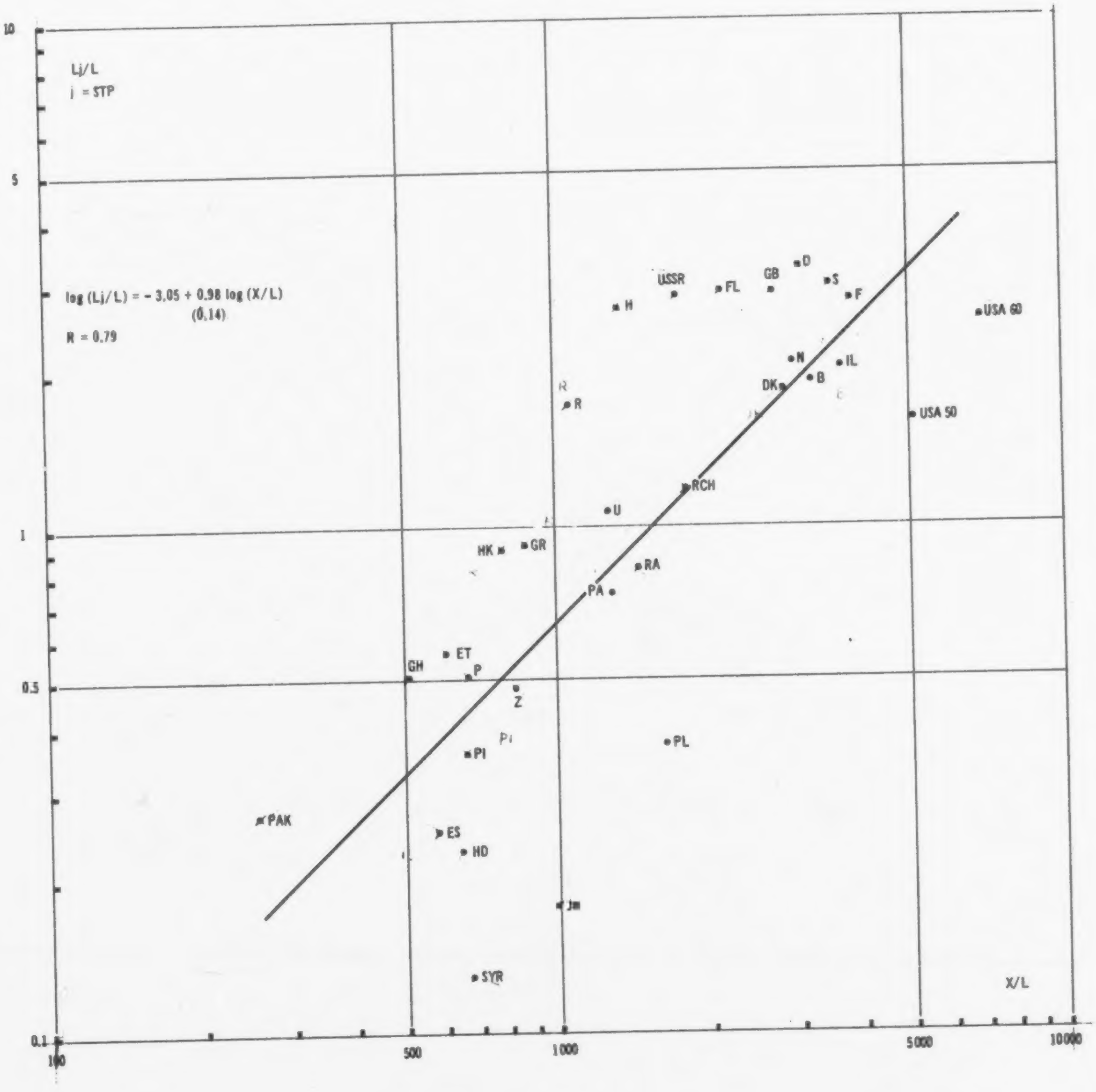
Graph II-2

WHOLE ECONOMY: ADMINISTRATIVE, EXECUTIVE AND MANAGERIAL WORKERS (Lj/L)
AND OUTPUT PER WORKER (X/L)



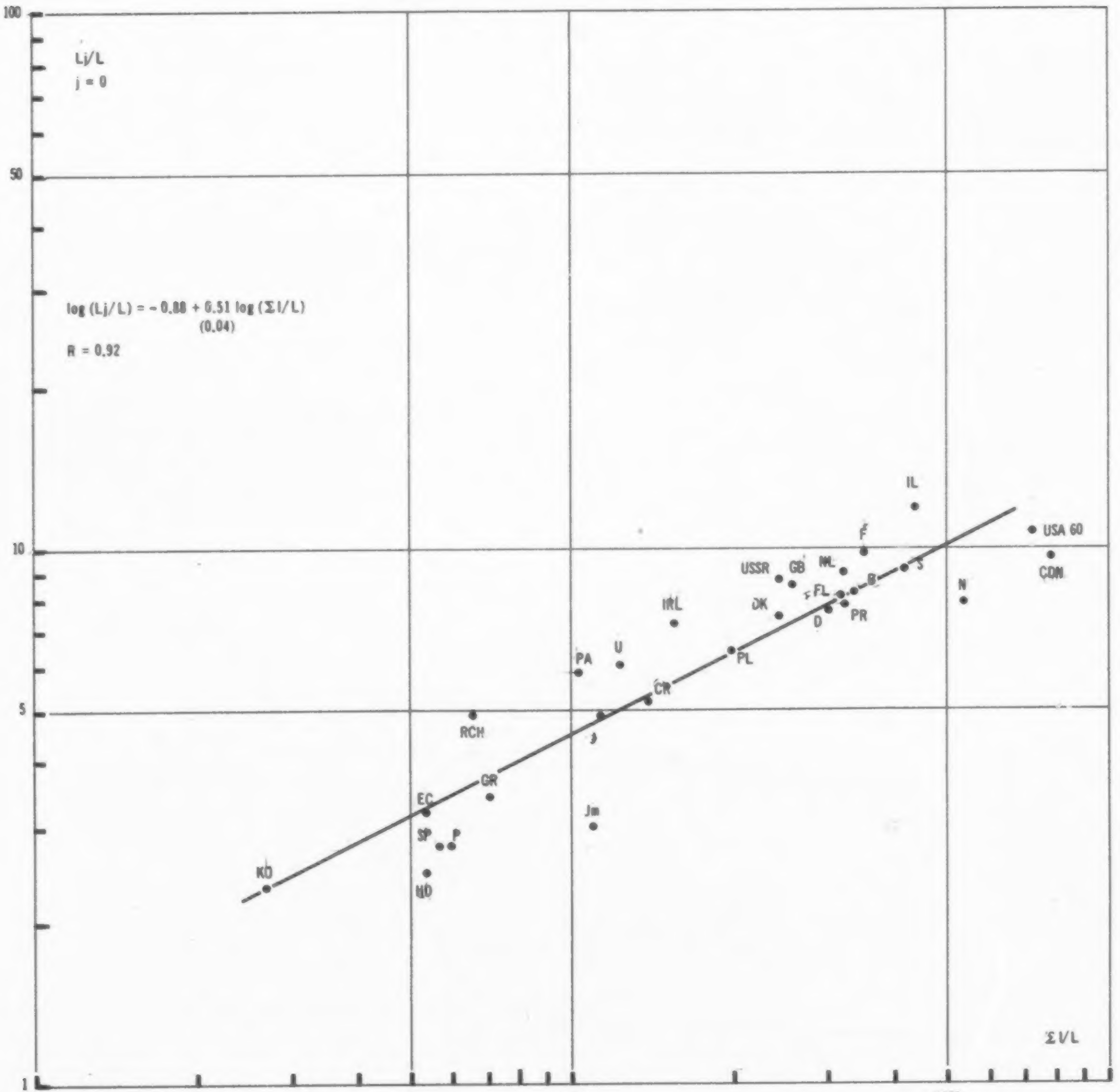
Graph II-3

WHOLE ECONOMY: SCIENTIFIC AND TECHNICAL PERSONNEL (Lj/L) AND OUTPUT PER WORKER (X/L)



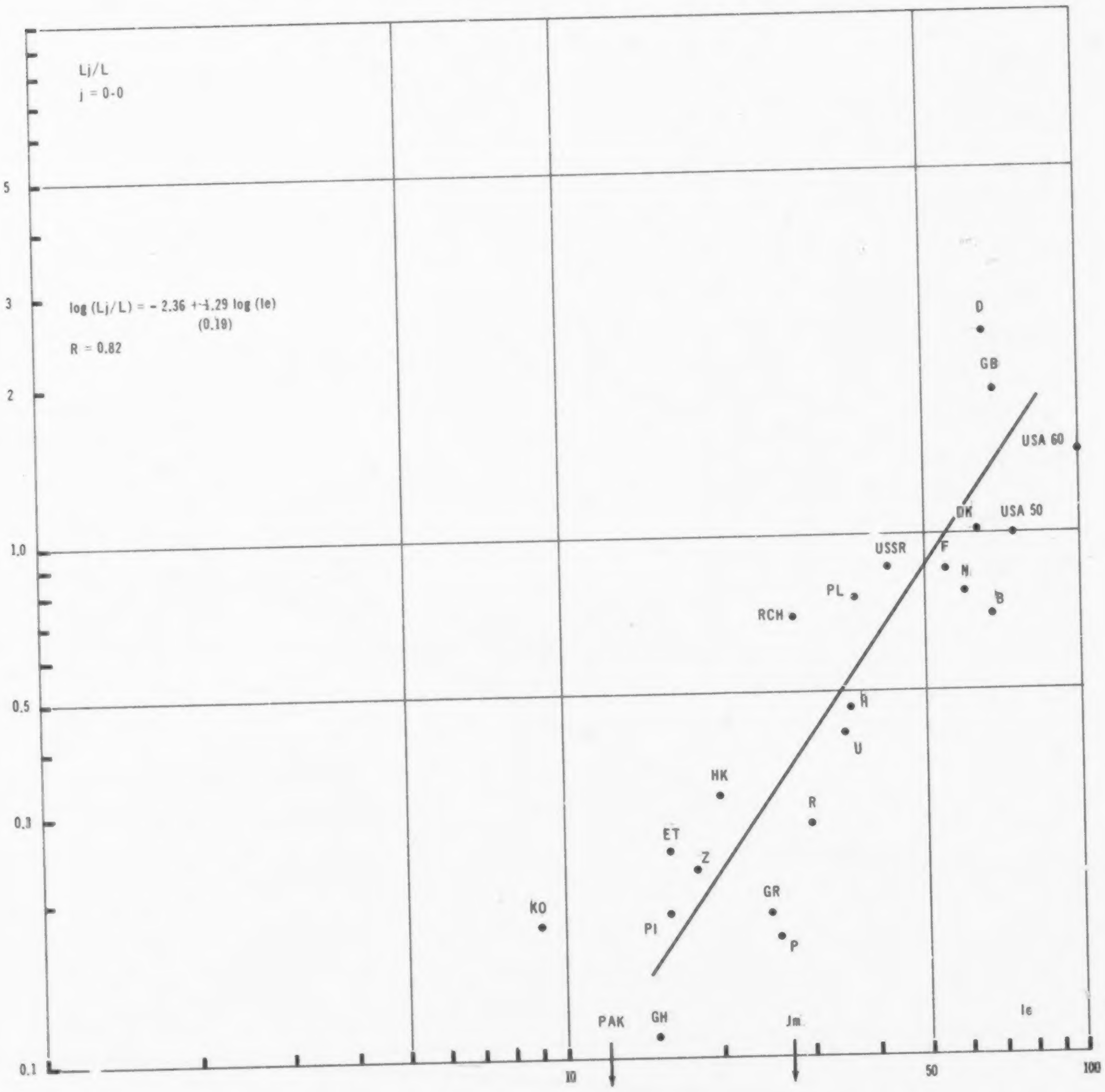
Graph II-4

WHOLE ECONOMY: PROFESSIONAL AND TECHNICAL WORKERS (Lj/L) AND GROSS CAPITAL FORMATION PER WORKER (ΣI/L)



Graph II-5

WHOLE ECONOMY : ARCHITECTS, ENGINEERS AND SURVEYORS (Lj/L) AND NON-MONETARY INDEX (Ie)



than the professional and technical personnel, as development proceeds. However, a note of caution is needed. Not only is the number of observations different, but the standard deviations attached to the b coefficients of the minor groups are much more important than for the major groups, so that careful interpretation is required. All this indicates that one can expect to find greatly different values for the occupational categories within the same development range; this may, in return, suggest the existence of substitution possibilities as between various occupational groups.

In order to push the examination a little further along these lines, we have presented five of the relationships in graphic form (Graphs II-1 to II-5). Graphs II-1 and II-4 show m. g. 0 in relation to X/L and $\Sigma I/L$, respectively. Table II-1 tells us that in both cases the correlation coefficients are very high (0.91 and 0.92, respectively) and the standard deviations of the regression coefficients quite low. A look at the two graphs clearly indicates that, even with such results, the value of the occupational percentage can vary substantially within a rather narrowly defined range of the explanatory variable. This is, for example, particularly striking in Graph II-1 at around the 700 dollar level of output per worker. But at higher levels of development, one can also notice clusters of countries with varying percentage values for their professional and technical workers category. These suggestions as to the importance of supply effects leading to substitution possibilities are, of course, even stronger in Graphs II-2, II-3 and II-5; all of these are depicting cases where the correlation coefficients are lower and the standard deviations higher than in the above two cases. Attention has to be drawn again to the quite considerable spread of the occupational values at the 600-700 dollar level of output per worker.

It must be said at once that other factors than supply effects can be responsible for the observed situation, e. g., measurement errors due to problems of classification and definition, exchange rate problems, capacity utilization, cyclical movements, etc. However, the fact that certain spreads are quite important, and that they persist whatever explanatory variable is used, strengthens the case for substitution possibilities.

2. MANUFACTURING INDUSTRIES

Table II-2 shows the outcome of the simple regression equations for manufacturing. It will be noted that, in general, the correlation coefficients are lower in this case than in those found at the level of the whole economy. There are two striking features: first, this time the sales workers are rather well correlated with the explanatory variables, particularly with X/L and In, at least as compared with the situation at the level for the whole economy; this occupational group appears to be better and more narrowly defined in this economic sector and appears to play an important role in the production process of the manufacturing industries. The share of this type of labour which can be found in manufacturing is, however, small, the bulk being employed in commerce. It is largely this fact - and the definitional problem of sales workers in commerce and services - that makes for the low and statistically non-significant correlation found for the whole economy.* The second feature is that the non-monetary indicator (In) is correlated with the major groups and with the engineering categories as well as or even better than is output per worker. It is important to underline the fact that, whereas the technologists (0-0 and 0-02) do show a definite and significant relationship with economic and technological development levels in this sector, this is not at all the case with the so-called pure scientists (minor group 0-1). Moving down towards the sector level does not improve the fit between the technicians' category and the explanatory variables, on the contrary. Combining 0-0 and 0-X gives, this time, significantly worse results than those obtained with 0-0 above. When comparing the outcome of the calculations for manufacturing with those for the whole economy, the difference in the number of observations will have to be borne in mind.

Contrary to what we saw for the whole economy, the b coefficients in manufacturing are much higher for the professional and technical workers (m. g. 0) than for any other major group. It is exactly unity with respect to the productivity variable, i.e. a one per cent change in Xm/Lm will tend to be accompanied by a one per cent change in the proportion of professional and technical workers in the sector, almost twice as much as the change in the proportion of managerial workers. This result is intuitively acceptable if it is remembered that, according to ISCO, working proprietors are included in the managerial category, and that they tend to decrease in numbers with a rise in the level of economic development and the consequent growth of industrial concentration. In general, however, the standard deviations of the regression coefficients are higher than for the whole economy; this is particularly striking for the minor groups, where the regression equations cannot be used for forecasting purposes.

The above considerations indicate the importance of some complementary graphical analysis. This has been done - each time in relation to sector productivity - for major group 0, the STP category, minor group 0-0, and unit-group 0-02. The results are shown in Graphs II-6 to II-9. They have in common the same striking feature: at given levels of sector productivity, the values of the occupational percentages may vary within a quite considerable range and, conversely, countries with a given value for their occupational percentage are found at quite different levels of sector productivity.

This "horizontal" and "vertical" evidence of substitution possibilities is perfectly well illustrated in Graph II-6, which depicts the relationship between professional and technical workers, on the one hand, and sector productivity, on the other. A glance at Table II-2 reminds us that the result of the regression analysis was better in this case than for the other three relationships depicted in Graphs II-7 to II-9, with a correlation coefficient of 0.80, a regression coefficient of 1.00, and

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* The correlation coefficient in commerce - anticipating a little on the analysis of this sector - between sales workers and sector productivity is - 0.52, and is significant at the 5% level. With rising levels of development, the number of sales workers in commerce diminishes, which is a consequence of the growing concentration of retail trade. The pattern is, however, very heterogeneous across countries, and it is no doubt because of the large proportion of shop-keepers (and street vendors in developing countries) in the total number of sales workers that the results for the whole economy - as reviewed in the previous section - are what they are.

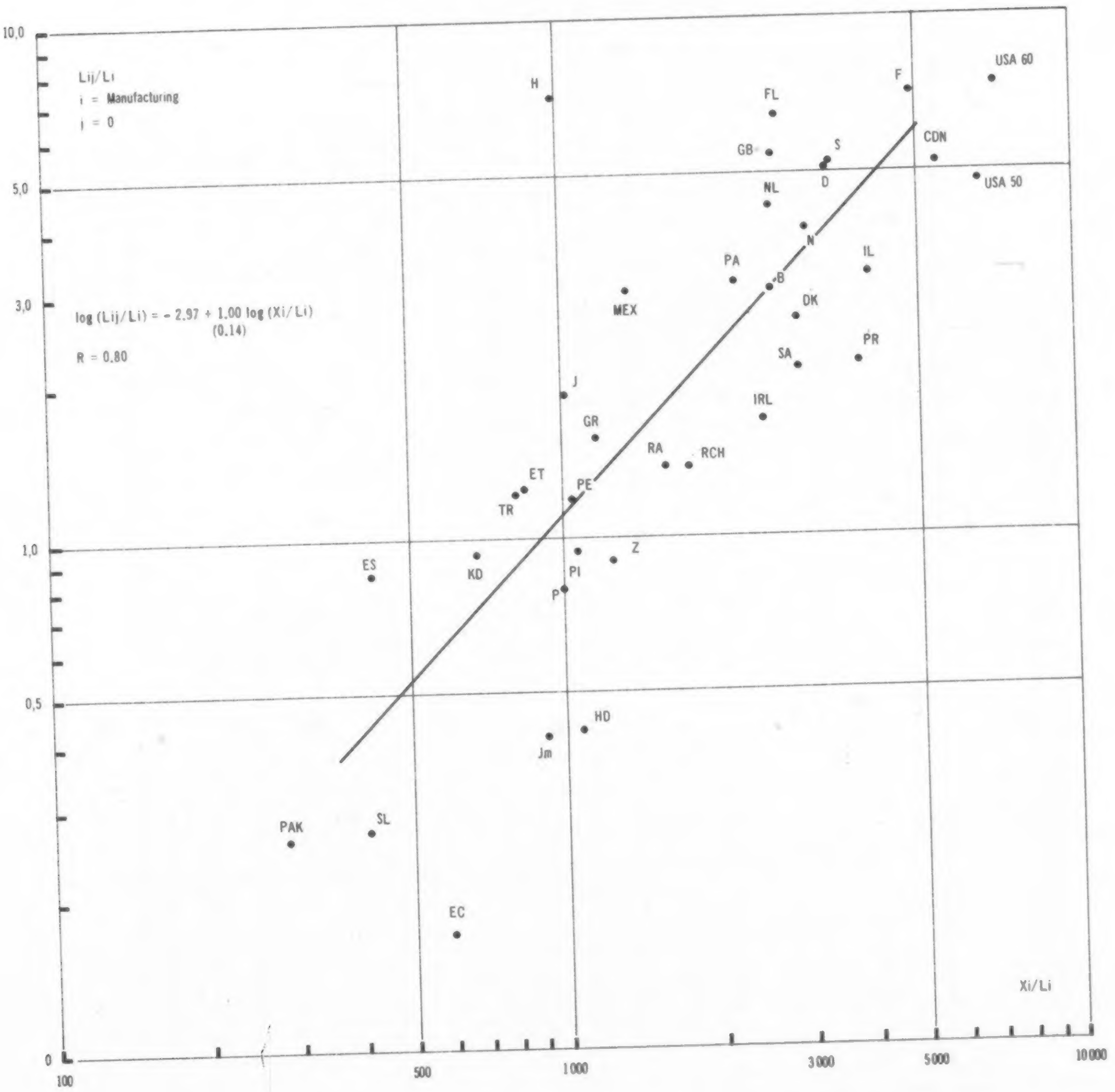
Table II-2. MANUFACTURING: REGRESSION EQUATIONS BETWEEN OCCUPATIONAL STRUCTURE (Lij/Li) AND ECONOMIC INDICATORS (n)

$$\log (Lij/Li) = \log a + b \log (n)$$

	OUTPUT PER WORKER: Xi/Li				NON-MONETARY INDEX: Ie				GROSS CAPITAL FORM. PER WORKER: Σ I/Li				SECTOR SHARE OF EMPLOYMENT: Li/L			
	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)
Major Groups:																
0	36	0,80*	-2,97	1,00(0,14)	40	0,82*	-2,06	1,51(0,19)	11	0,70*	-2,40	0,87(0,29)	40	0,67*	-1,46	1,35(0,24)
1	35	0,67*	-1,54	0,59(0,12)	40	0,73*	-1,23	0,99(0,16)	11	0,48	-0,59	0,33(0,21)	40	0,52*	-0,07	0,80(0,21)
0+1	35	0,80*	-1,67	0,72(0,10)	40	0,84*	-1,27	1,22(0,14)	11	0,80*	-0,83	0,51(0,14)	40	0,66*	-0,70	1,05(0,19)
2	35	0,79*	-1,43	0,65(0,10)	40	0,85*	-0,91	1,04(0,11)	11	0,69*	-0,89	0,52(0,18)	40	0,72*	-0,53	0,97(0,15)
3	35	0,74*	-3,02	0,96(0,17)	40	0,57*	-1,39	0,99(0,25)	11	0,23			40	0,44*	-0,97	0,91(0,30)
0+1+2+3	35	0,84*	-1,19	0,69(0,09)	40	0,85*	-0,62	1,08(0,12)	11	0,62*	0,04	0,36(0,15)	40	0,71*	-0,20	0,99(0,16)
Minor Groups:																
0-0	16	0,75*	-4,85	1,39(0,36)	14	0,75*	-3,04	1,74(0,43)					14	0,73*		
0-1	18	0,13			18	0,06							20	0,07		
0-X	16	0,50*	-4,11	1,17(0,54)	15	0,48*	-0,92	1,19(0,61)					18	0,66*	-3,37	2,31(0,66)
0-0+0-X	21	0,65*	-3,49	1,10(0,28)	21	0,50*	-0,48	1,04(0,41)					25	0,64*	-2,29	1,78(0,44)
STP	22	0,65*	-3,18	1,03(0,43)	22	0,50*	-0,41	1,02(0,39)					25	0,63*	-2,11	1,68(0,43)
0-02	12	0,80*	-3,35	0,96(0,25)	10	0,86*	-1,12	1,46(0,31)					12	0,75*	-2,55	1,76(0,48)

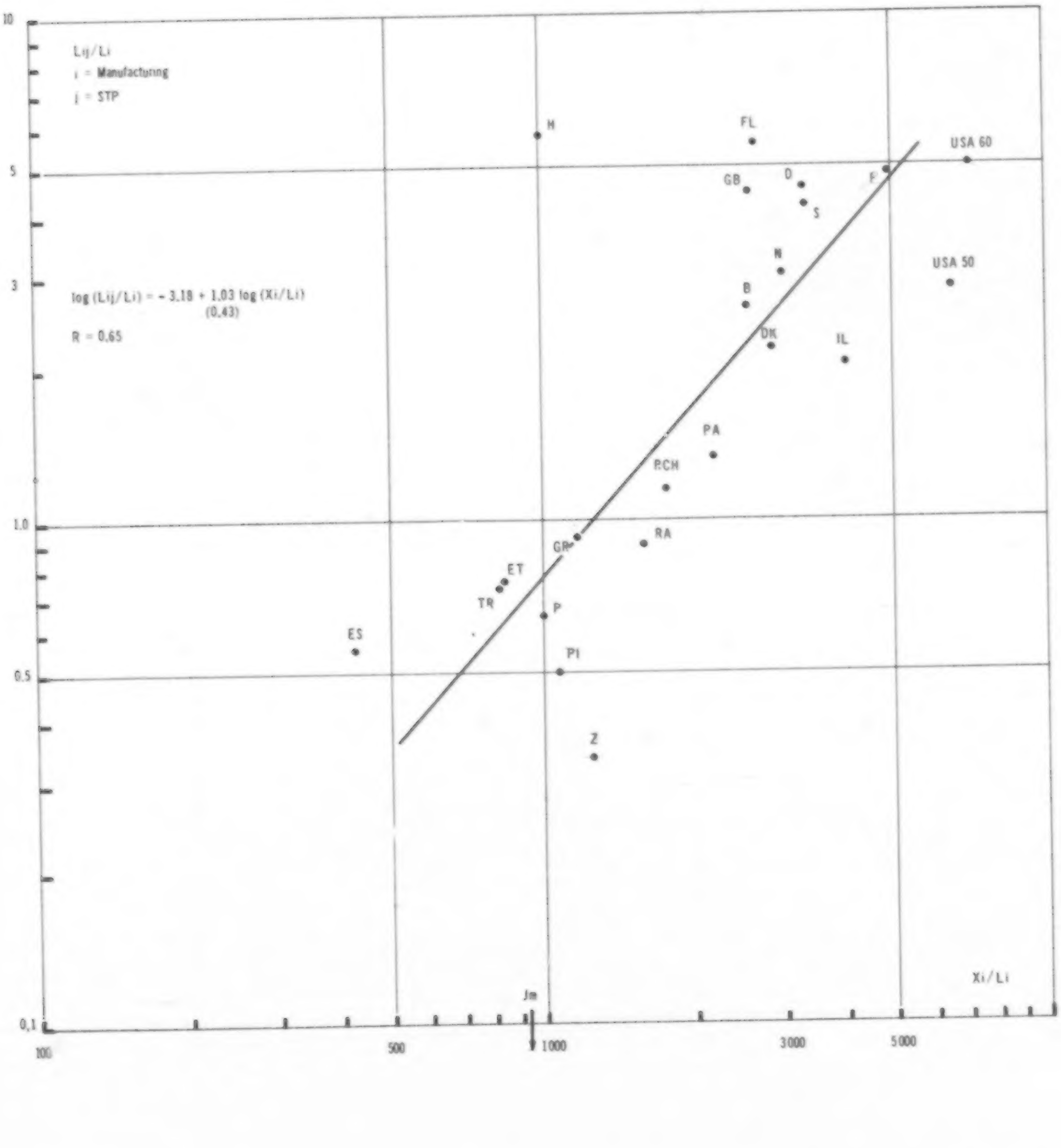
Graph II-6

MANUFACTURING: PROFESSIONAL AND TECHNICAL WORKERS (Lij/Li) AND SECTOR OUTPUT PER WORKER (Xi/Li)



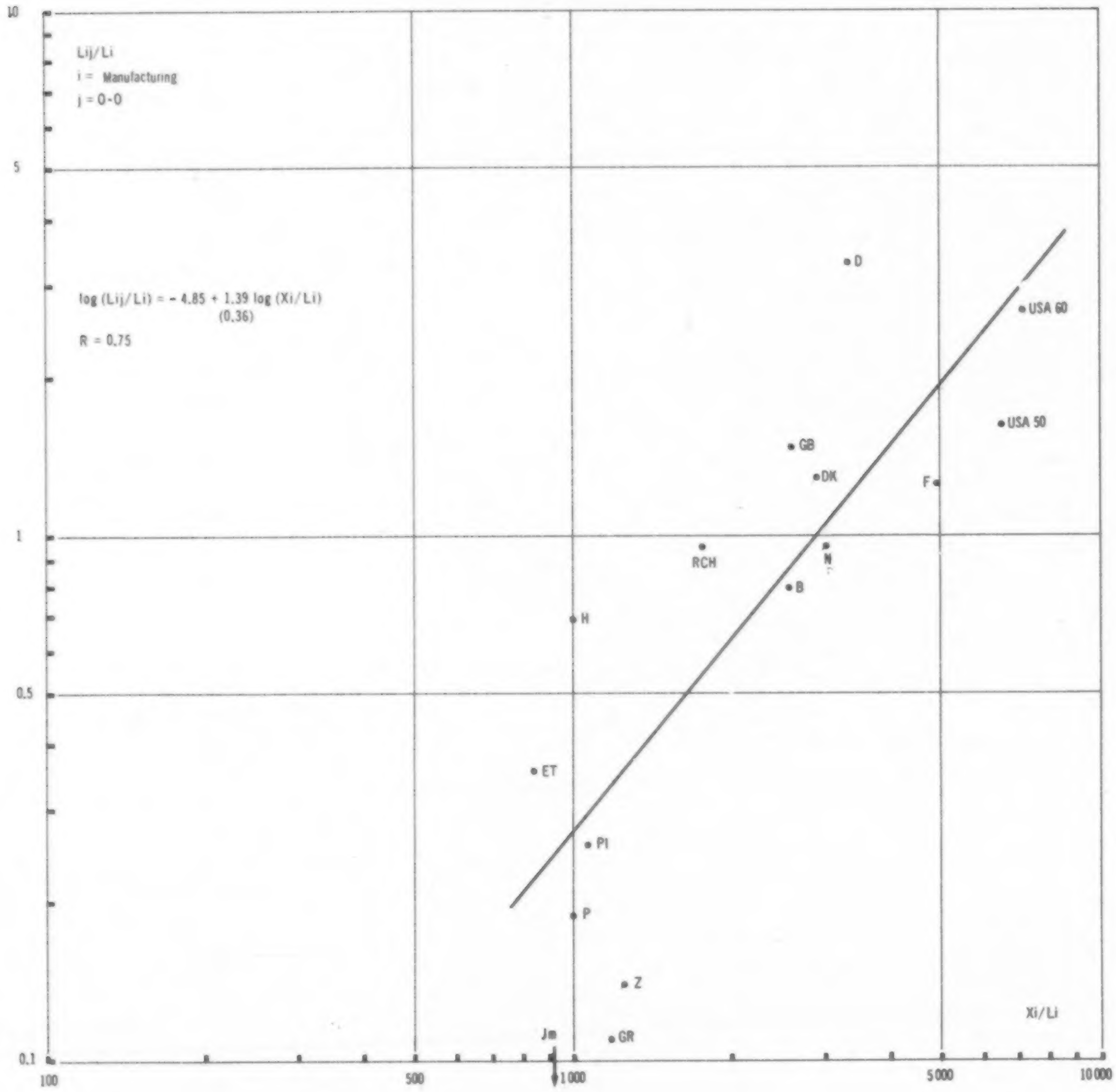
Graph II-7

MANUFACTURING: SCIENTIFIC AND TECHNICAL PERSONNEL (Lij/Li)
AND SECTOR OUTPUT PER WORKER (Xi/Li)



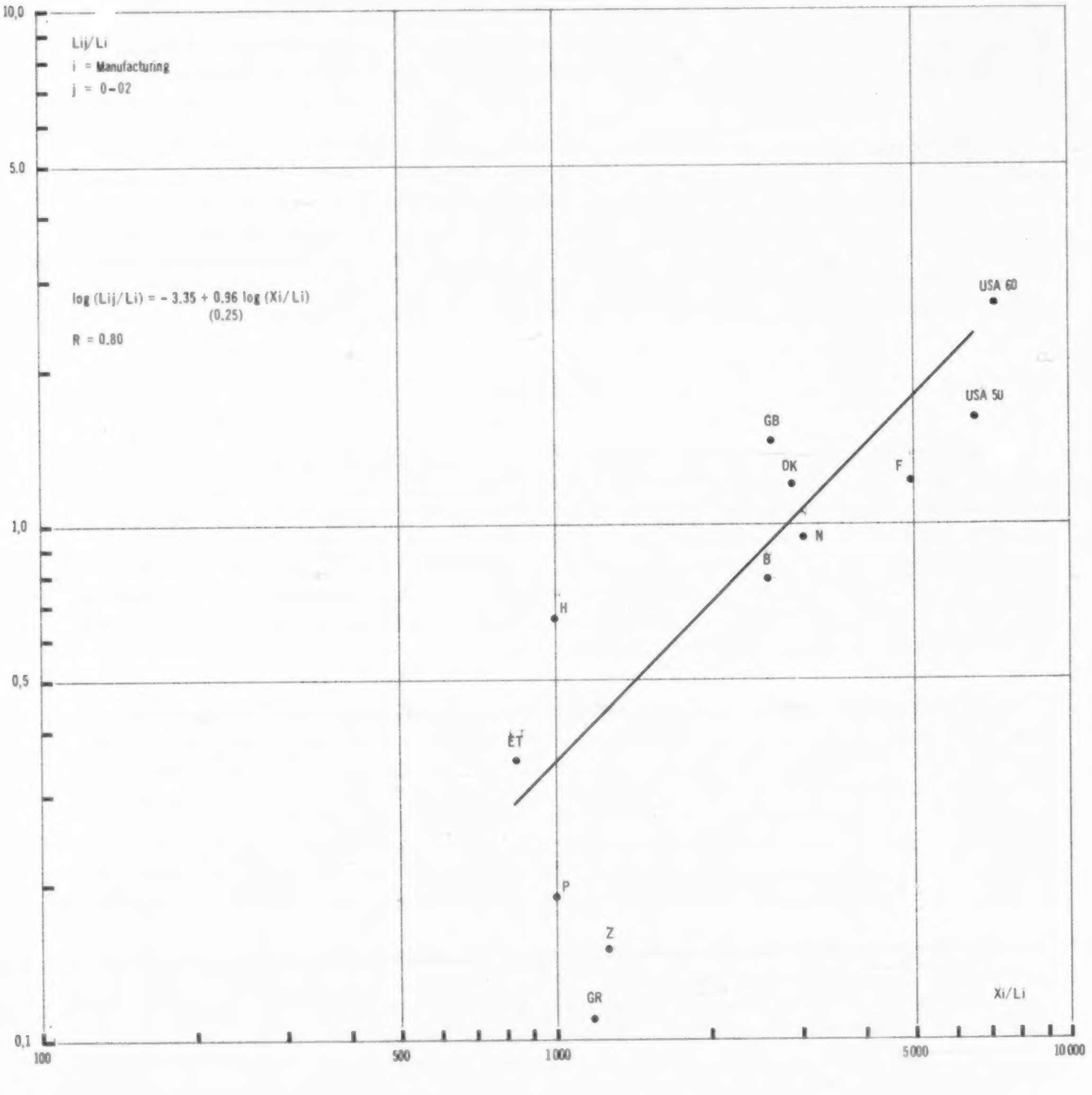
Graph II-8

MANUFACTURING: ARCHITECTS, ENGINEERS AND SURVEYORS (Lij/Li) AND SECTOR OUTPUT PER WORKER (Xi/Li)



Graph II-9

MANUFACTURING: ENGINEERS (Lij/Li)
AND SECTOR OUTPUT PER WORKER (Xi/Li)



a standard deviation of 0.14. Although the trend is quite clear, deviations from the trend are very important (as summarized in the value of standard deviation). Thus, as for the "vertical" evidence, we can refer to the wide ranges of the occupational values at the 1,000 and 3,000 dollar levels of productivity. The "horizontal" evidence is illustrated at the level of the three and five per cent occupational values, for example. Analogous, and even stronger, evidence is shown in Graphs II-7 to II-9.

Attention has to be drawn again to factors other than supply which could explain, at least partly, the above results, such as classification and definition problems, exchange rate problems and, above all, the sector composition of output. There is no doubt that this latter factor is particularly important in explaining part of the deviations observed. How important this factor exactly is could only be determined on a case-study basis and at a higher level of sector disaggregation.

3. SERVICES

Table II-3 presents the results of the regression analysis for the services sector (sector 8 of ISIC). In this case, sector productivity has been replace by GDP per capita (X/P), and the economic non-monetary index, by the "social" index (Is) which includes the number of doctors and dentists, post-primary school enrolments, the degree of literacy and the number of newspapers and radios. It can, therefore, be considered as a good indicator of the level, if not of productivity, then at least of activity of a large part of this sector.

A glance at Table II-3 shows that the correlation coefficients are low and that many of them are non-significant. GDP per capita comes out on top, whereas the sector share of labour is not related to the occupational structure at all. Analogous observations can be made with regard to the regression coefficients: their values are low and their standard deviations relatively important. Interestingly enough, the engineering categories show again the best correlation coefficients, although the standard deviations of the b coefficients are rather formidable.

Graphs II-10 to II-13 depict the relationship between X/P, on the one hand, and major group 0, the STP category, major group 1 and 2 respectively, on the other. They are impressive evidence of the erratic nature of these relationships. There are probably two main reasons for this state of affairs: one is the irregular behaviour of the relative weight of the services sector in total employment as development proceeds, and the other relates to the kind of HLM in this sector for which the supply effects are probably important. The former reason - which is reflected in countries having about the same sector share of employment in services at various levels of development - has, of course, a distorting impact on the occupational percentage values; this is one of the reasons why it is sometimes preferable to work with occupational coefficients rather than with the percentage distribution, as will be explained in Annex C.* The bulk of HLM in this sector consists of medical personnel, jurists and teaching staff. The first two categories, in particular, are frequently considered as "traditional" fields of study where the supply

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* The occupational input coefficient is defined as the number of people in a certain occupation and employed in a certain sector necessary to produce a unit of output (one million US dollars) in that sector.

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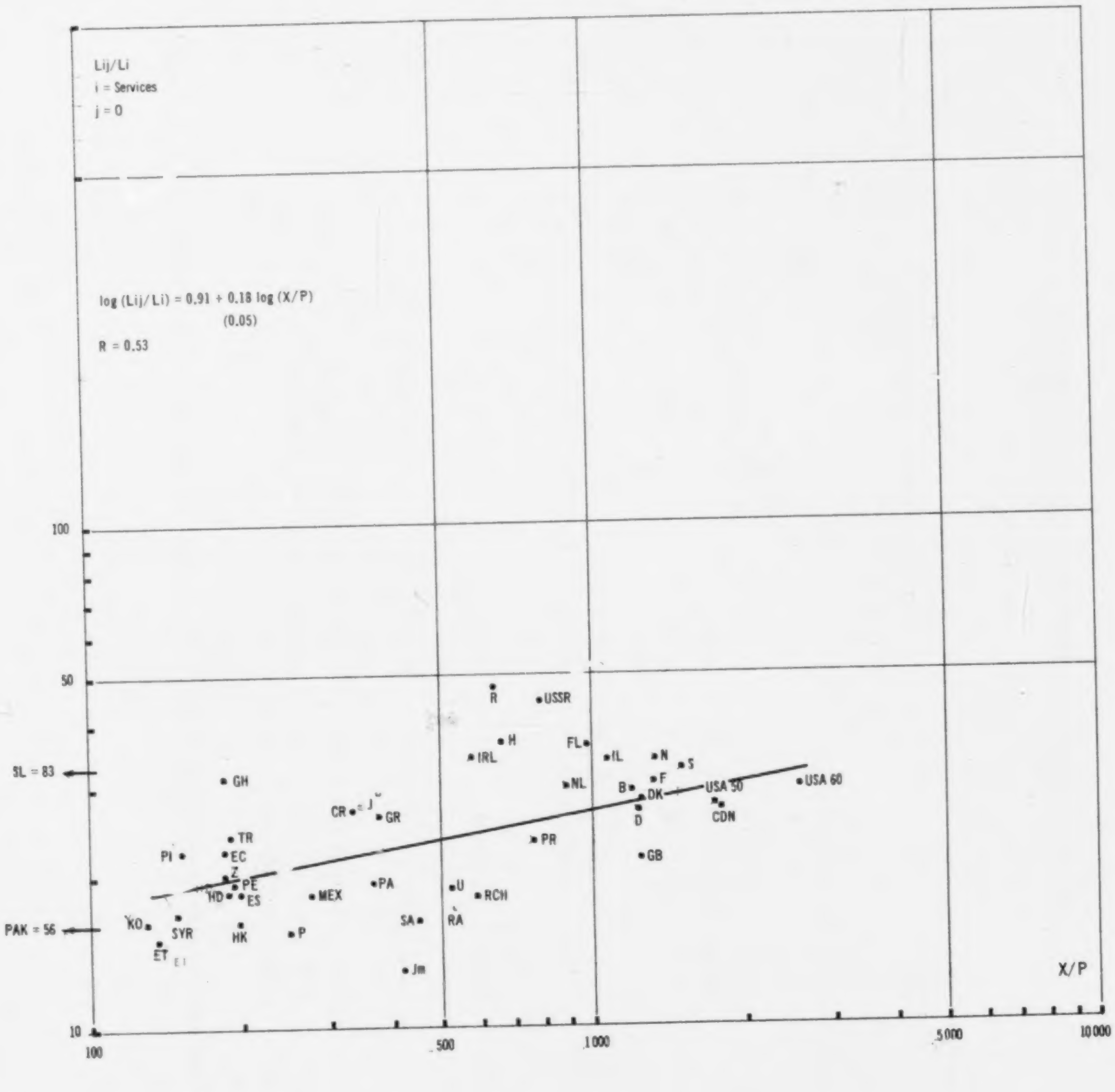
Table II-3. SERVICES: REGRESSION EQUATIONS BETWEEN OCCUPATIONAL STRUCTURE (Lij/Li) AND ECONOMIC INDICATORS (n)

log (Lij/Li) = log a + b log (n)

	GDP PER CAPITA: X/P				NON-MONETARY INDEX: Σ Is				SECTOR SHARE OF EMPLOYMENT: Li/L			
	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)
Major Groups:												
0	43	0.53*	0.91	0.18(0.05)	39	0.41*	1.12	0.18(0.06)	42	0.04		
1	42	0.43*	-0.25	0.28(0.09)	38	0.26			41	0.16		
0+1	42	0.57*	0.92	0.19(0.05)	38	0.44*	1.16	0.18(0.06)	42	0.01		
2	42	0.26			38	0.29			41	0.31	0.78	0.23(0.11)
3	43	0.13			39	0.28			42	0.25		
0+1+2+3	42	0.58*	1.20	0.16(0.04)	38	0.51*	1.37	0.16(0.05)	41	0.13		
Minor Groups:												
0-0	20	0.63*	-1.81	0.61(0.18)	17	0.62*	-1.47	0.85(0.28)	19	0.30		
0-1	20	0.41	-2.20	0.47(0.24)	18	0.46	-2.16	0.77(0.37)	19	0.11		
0-2	23	0.25			21	0.33			22	0.34		
0-X	20	0.32			17	0.40			19	0.35		
STP	27	0.56*	-0.83	0.42(0.12)	24	0.59*	-0.67	0.62(0.18)	26	0.05		
0-0+0-X	27	0.62*	-1.09	0.48(0.12)	24	0.62*	-0.85	0.68(0.18)	26	0.08		
0-02	15	0.64*	-1.65	0.49(0.16)	12	0.40			14	0.44		
1-1	22	0.39			19	0.29			22	0.59*	-1.97	1.62(0.50)

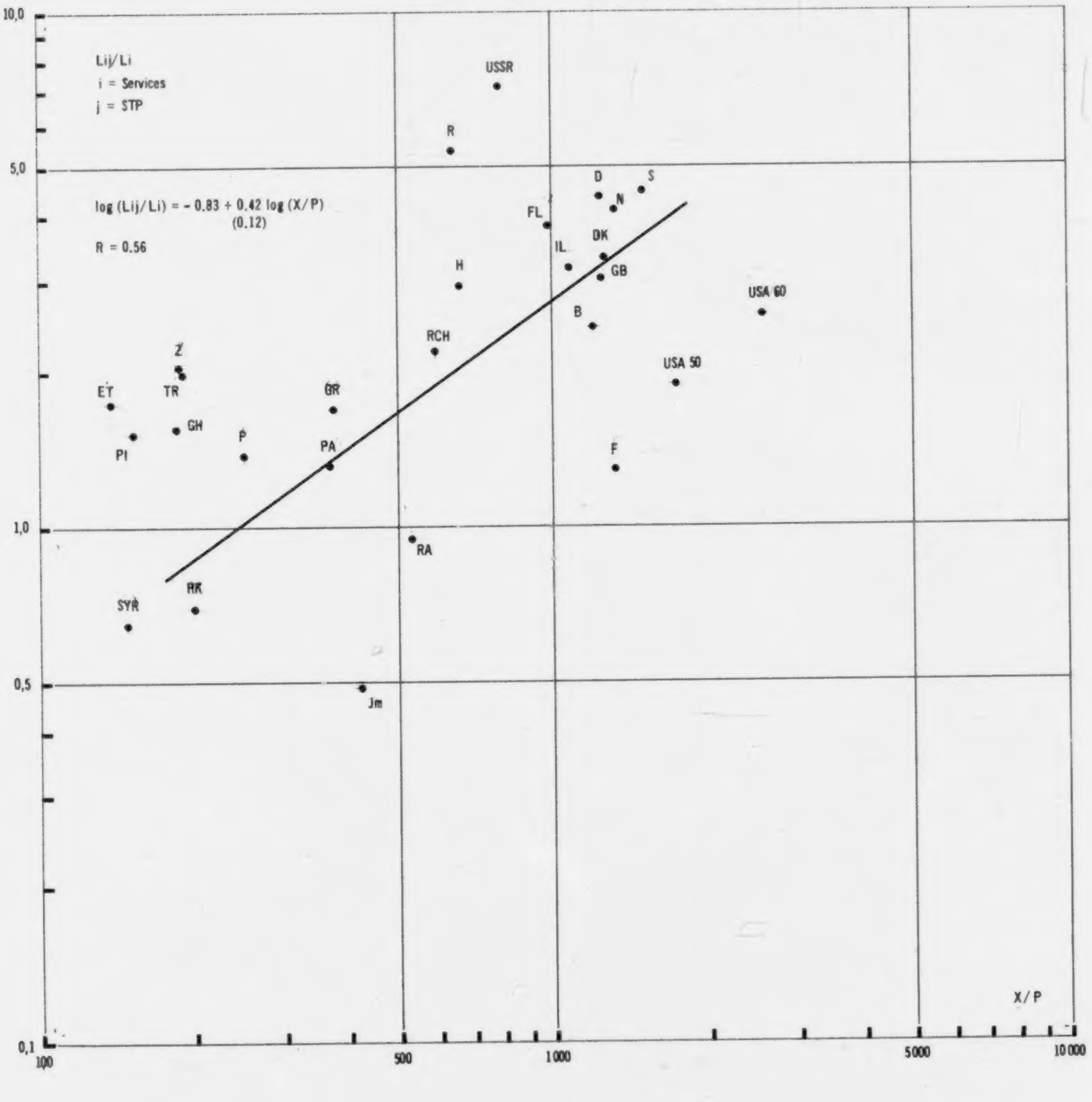
Graph II-10

SERVICES: PROFESSIONAL AND TECHNICAL WORKERS (Lij/Li)
AND GDP PER CAPITA (X/P)



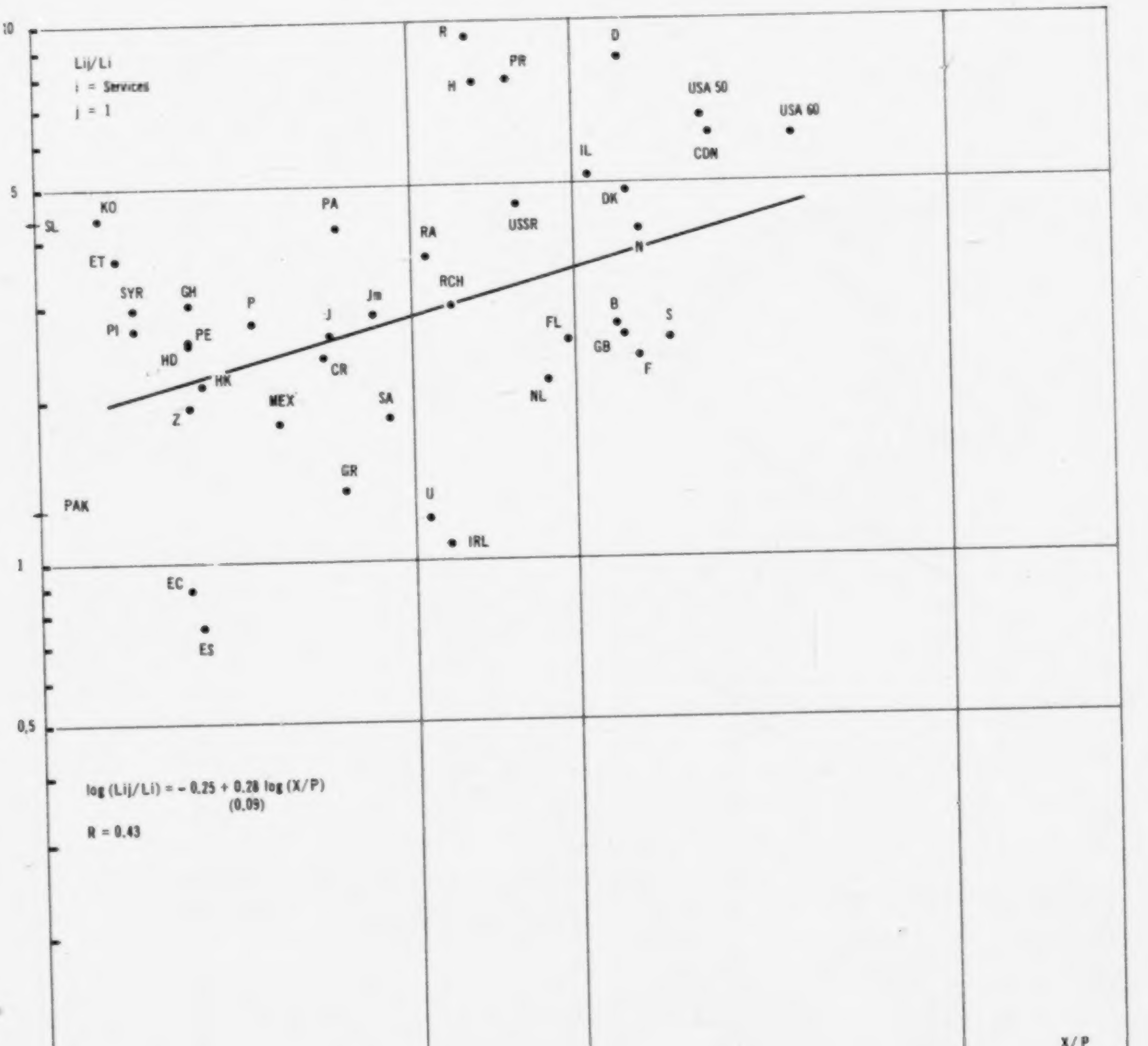
Graph II-11

SERVICES: SCIENTIFIC AND TECHNICAL PERSONNEL (Lij/Li) AND GDP PER CAPITA (X/P)



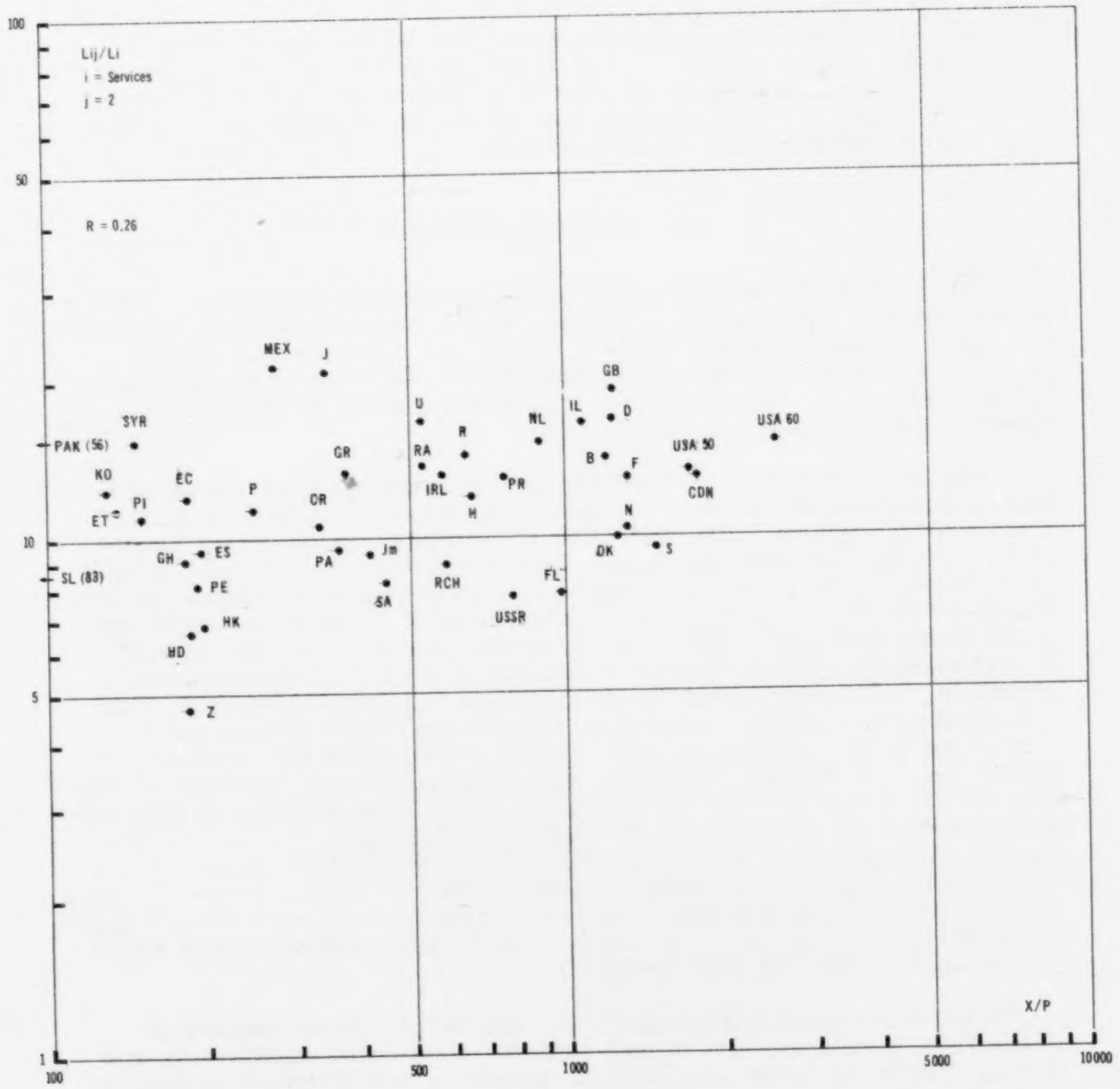
Graph II-12

SERVICES: ADMINISTRATIVE, EXECUTIVE AND MANAGERIAL WORKERS (Lij/Li) AND GDP PER CAPITA (X/P)



Graph II-13

SERVICES: CLERICAL WORKERS (Lij/Li) AND GDP PER CAPITA (X/P)



effects may thus be important. It must be noted, moreover, that the three above-mentioned occupational groups are not usually related to economic and technological variables, but rather to demographic and enrolment variables.

All this undoubtedly explains a great deal of the results as given in Table II-3 and as shown in Graphs II-10 to II-13. Quite clearly the services sector functions frequently as a "reservoir" for "non-manual" manpower, and no clear occupational pattern emerges for this sector with rising overall levels of development.

4. AGRICULTURE

The results of sector 0 of ISIC are presented in Table II-4. Two sector specific non-monetary indicators have been introduced, namely, fertilizer consumption per worker (F/Li), and tractors per worker (T/Li). The sources from which this information was drawn are indicated in Annex A. Both variables can be considered as indicators of agricultural technology in use.

The primary sector is probably less appropriate than any other for international comparisons of occupational structures. This is so for a number of reasons. The definition of the agricultural labour force differs greatly between countries; thus, the proportion of HLM in total agricultural employment will depend to a large extent on whether or not family workers are included in the denominator. The inclusion or not of the unemployed will also be of particular importance. But even if this problem is solved, there remains the degree of disguised unemployment, which may affect the denominator (Li) very differently from one country to another. It could be argued that these differences will cancel out when L enters on both sides of the equation (for example, in both Lij/Li and Xi/Li). However, the effect on Lij will be much greater than on Xi, since even the biggest Lij/L under consideration in this economic sector (all non-manual workers taken together: 0 + 1 + 2 + 3) rarely exceeds 2.5%. It will be realized that the distorting factors we have spelled out are analogous to those mentioned above for the services sector, when it was also mentioned that in such cases occupational coefficients (with Xi instead of Li in the denominator) would be more appropriate for the analysis (see Annex C).

With these qualifications in mind, and turning to the results of Table II-4, it is important to note that the correlation coefficients are higher than those found in services. However, the standard deviations of the b coefficients are again quite substantial. It is also important to draw attention to the fact that the two non-monetary "technological" indicators are better related to the minor-groups than the sector productivity and investment variables.

All in all, however, and granting the difficulties of measurement referred to above, the size of the standard deviations suggests that various occupational structures are possible at given levels of agricultural development and technology as reflected in our explanatory variables.

Table II-4. AGRICULTURE: REGRESSION EQUATIONS BETWEEN OCCUPATIONAL STRUCTURE (Lij/Li) AND ECONOMIC INDICATORS (n)

$$\log (L_{ij}/L_i) = \log a + b \log (n)$$

	OUTPUT PER WORKER: Xi/Li				GROSS CAPITAL FORM. PER WORKER: Σ I/Li				FERTILIZER CONSUMPTION PER WORKER: F/Li				TRACTORS PER WORKER: T/Li			
	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)
Major Groups:																
0	39	0.67*	-3.17	0.83(0.15)	19	0.70*	-2.38	0.60(0.15)	27	0.62*	-1.35	0.33(0.08)	24	0.69*	-1.22	0.37(0.08)
1	28	0.61*	-3.54	0.85(0.22)	14	0.50*	-2.34	0.48(0.24)	22	0.31			18	0.46		
0+1	28	0.73*	-2.71	0.75(0.14)	15	0.78*	-2.13	0.57(0.13)	22	0.49*	-0.99	0.26(0.10)	18	0.64*	-0.96	0.32(0.09)
2	35	0.40*	-2.09	0.51(0.20)	17	0.41	-1.83	0.43(0.25)	22	0.36			18	0.33		
Minor Groups:																
0-2	19	0.53*	-3.40	0.82(0.31)	15	0.22			16	0.56*	-2.08	0.49(0.20)	15	0.47		
0-X	14	0.33			11	0.45			11	0.48			10	0.64*	-1.93	0.36(0.15)
0-2+0-X	24	0.48*	-3.19	0.76(0.30)	15	0.22			18	0.71*	-2.08	0.56(0.14)	16	0.58*	-1.55	0.46(0.15)
STP	25	0.56*	-3.22	0.80(0.25)	15	0.36			19	0.72*	-1.85	0.50(0.11)	17	0.73*	-1.43	0.44(0.11)

5. MINING

Three explanatory variables are used for the occupational analysis of this economic sector: sector productivity, gross capital formation per worker, and the sector share of output. The latter has thus replaced the sector share of employment, which is logical in view of the capital intensity of this sector.

The value of the mining sector's output is particularly sensitive to the year of estimation. A country with an important production of silver, diamonds or bauxite will, if the year of reference coincides with a "peak" year, show a very high figure for its sector productivity which may have little to do with the technology used and, even less, with technological requirements in terms of the occupational composition. Great care has, therefore, been taken to exclude, where necessary, certain countries with extreme productivity values. It also follows from this that the composition of output may play a distorting role in cross-country comparisons of this sector. Unfortunately, relevant information for the important variable $\Sigma I/Li$ could only be collected for 14 countries.

The results of the calculations are presented in Table II-5. They are rather analogous to those found for agriculture: relatively low correlation coefficients and high standard deviations attached to the regression coefficients. These findings lead to the same conclusions as those drawn at the end of the previous section.

6. CONSTRUCTION

As becomes clear from an examination of Table II-6, the results of the regression analyses for this sector are among the "worst" obtained so far. Besides the productivity variable, two non-monetary explanatory variables have been used, namely, output of dwellings per worker (D/Li), and cement production per capita (Ce/P). The investment variable had to be excluded for want of data. The results with the "size variable" (Li/L) are not given, because they were totally inconclusive.

In the light of the results obtained with the two non-monetary variables just mentioned, we shall say only a few words about the analyses performed with sector productivity as the independent variable. It will be noted that the correlation coefficient of major group 0 is significant, while the one for managerial workers is not. Combining these two occupational groups makes for a significant improvement in the correlation coefficient and a considerable drop in the standard deviation. This relationship has been depicted in Graph II-14, which again suggests considerable substitution possibilities, although the impact of classification and definitional errors is probably exceptionally important in this sector (see, for example, the situation of Greece on the graph).

At the level of the minor groups, only the coefficients for the STP and the engineering categories are significant, although the standard deviations remain high. Whatever the importance of the measurement errors may be, it could hardly contradict the conclusion that - at least on the basis of the present evidence - there appears to be a rather wide variety of possible occupational structures at analogous levels of development in the construction sector.

Table II-5. MINING: REGRESSION EQUATIONS BETWEEN OCCUPATIONAL STRUCTURE (Lij/Li) AND ECONOMIC INDICATORS (n)

log (Lij/Li) = log a + b log (n)

	OUTPUT PER WORKER: Xi/Li				GROSS CAPITAL FORM. PER WORKER: Σ I/Li				SECTOR SHARE IN GDP: Xi/X			
	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)
Major Groups:												
0	35	0.52*	-1.66	0.60(0.17)	14	0.76*	-1.47	0.55(0.13)	31	0.49*	0.35	0.32(0.12)
1	35	0.31	-1.41	0.43(0.23)	14	0.59*	-2.07	0.60(0.24)	31	-0.19		
0+1	35	0.58*	-1.16	0.52(0.13)	14	0.80*	-1.29	0.55(0.12)	31	0.15		
2	35	0.12			14	0.59*	-0.15	0.21(0.09)	31	0.25	0.57	0.12(0.09)
3	35	-0.05			14	0.20			31	-0.12		
0+1+2+3	35	0.26	0.19	0.23(0.13)	14	0.64*	-0.12	0.31(0.11)	31	0.18		
Minor Groups:												
0-0	16	0.61*	-1.78	0.53(0.18)					14	0.67*	-0.01	0.35(0.11)
0-1	22	0.49*	-4.67	1.10(0.44)					20	0.37	-0.89	0.47(0.27)
0-X	17	0.33	-2.86	0.68(0.50)					15	0.35	-0.63	0.44(0.33)
STP	24	0.54*	-1.99	0.65(0.21)					21	0.53*	0.23	0.35(0.13)
0-02	15	0.44	-3.02	0.81(0.46)					14	0.62	-0.29	0.63(0.23)

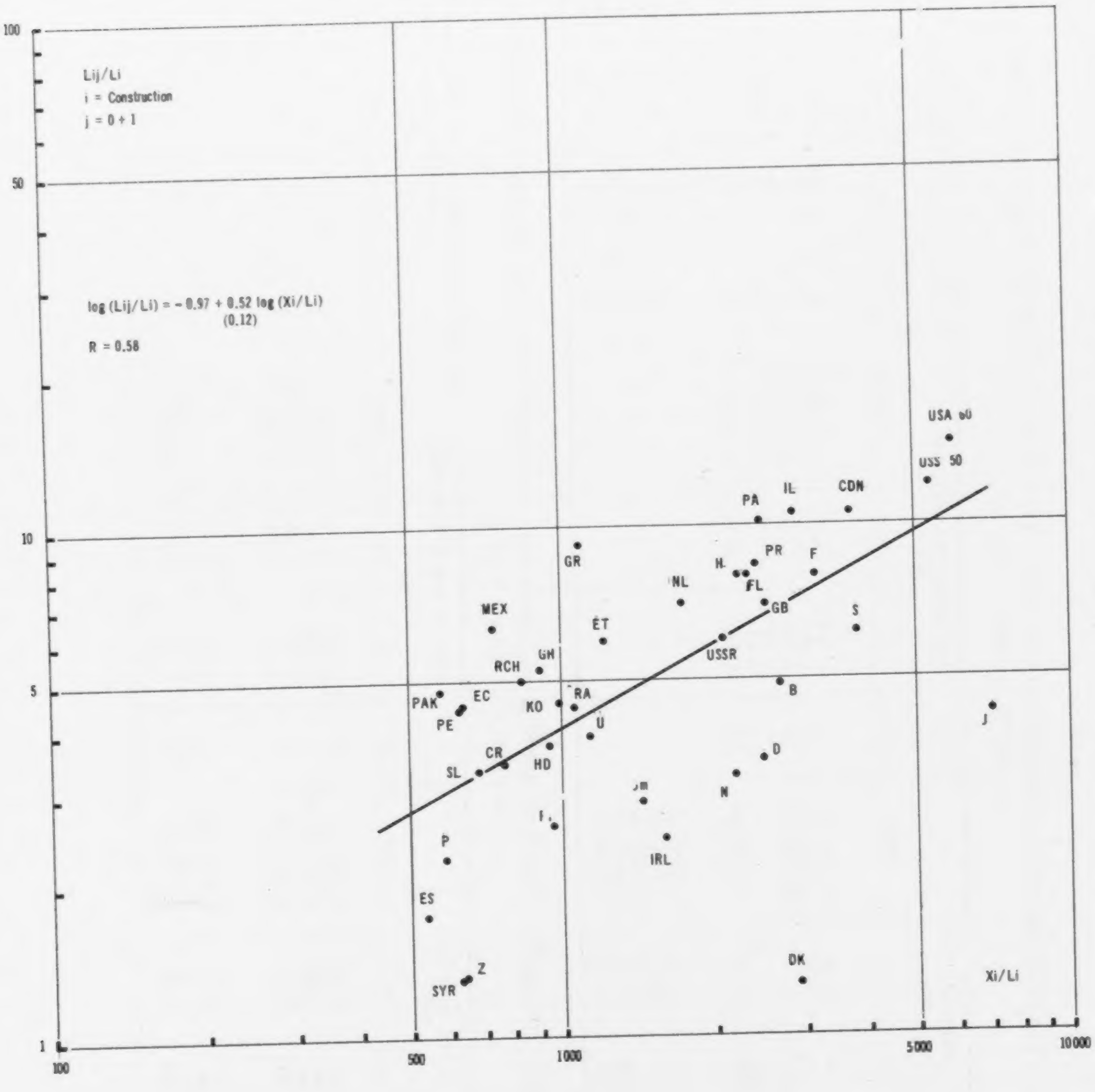
Table II-6. CONSTRUCTION: REGRESSION EQUATIONS BETWEEN OCCUPATIONAL STRUCTURE (Lij/Li) AND ECONOMIC INDICATORS (n)

log (Lij/Li) = log a + b log (n)

	OUTPUT PER WORKER: Xi/Li				OUTPUT OF DWELLINGS PER WORKER: D/Li				CEMENT PRODUCTION PER CAPITA: Ce/P			
	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)
Major Groups:												
0	41	0.44*	-1.33	0.54(0.18)	28	0.36*	-0.21	0.52(0.26)	40	0.19	-0.06	0.16(0.14)
1	39	0.28	-1.25	0.46(0.26)	27	0.39*	-0.84	0.80(0.38)	38	0.09		
0+1	39	0.58*	-0.97	0.52(0.12)	27	0.58*	-0.09	0.63(0.18)	38	0.28	0.34	0.17(0.09)
2	39	0.45*	-0.96	0.42(0.14)	27	0.36	-0.03	0.38(0.19)	38	0.37*	-0.11	0.22(0.09)
Minor Groups:												
0-0	21	0.32	-1.24	0.42(0.28)	15	0.20			21	0.11		
0-X	19	0.29	-2.60	0.71(0.57)	14	0.08			19	0.19		
STP	26	0.51*	-2.24	0.80(0.28)	19	0.35	-0.96	1.06(0.70)	26	0.30	-0.53	0.42(0.27)
0-02	17	0.52*	-2.37	0.73(0.31)	16	0.19			17	0.27	-0.69	0.33(0.31)

Graph II-14

CONSTRUCTION: PROFESSIONAL AND MANAGERIAL PERSONNEL (Lij/Li) AND SECTOR OUTPUT PER WORKER (Xi/Li)



7. ELECTRICITY, GAS AND WATER

This small sector of industrial activity comprises mainly the production of energy from various sources, but also water supply and sanitary services. It is, therefore, a rather heterogeneous sector from the product composition point of view: it falls really in between industrial and service activities.

The energy producing part of the sector, in industrial countries, usually has a highly sophisticated technology, extremely capital-intensive and also more "white-collar" - intensive than any other primary or secondary sector. It follows that the denominator in Lij/Li is usually quite small: even in the United States of America, there were less than one million workers in the sector in 1960, or little over one per cent of total employment. The results of the analyses will, therefore, be particularly sensitive to errors in the classification of sector employment.

Two non-monetary variables are included in the analysis: total production of energy in tons of coal equivalent per worker in the sector (Ep/Li)*, and gross energy consumption in kg. of coal equivalent per capita (E/P).** The former only refers to part of the sector under review (because of the water and sanitary services), whereas the latter is not a sector specific technological indicator as it also includes imports (important for many developing countries) and because it has total population in the denominator. These facts may partly explain the results for those two variables as indicated in Table II-7.

The results with the two other variables (Xi/Li and ΣI/Li) lead to the same kind of conclusions as those reached in the sectors reviewed previously.

8. TRANSPORT AND COMMUNICATIONS

The services in this sector include, besides rail, road, water and air transport, storage and warehousing, and communication services by post, wire and radio. As other service sectors, this is a very heterogeneous one, and it can be expected a priori that this will also be reflected in the results of our calculations.

Three explanatory variables are shown in Table II-8: they are sector output per worker, commercial vehicles per worker (C/Li), and number of telephones per worker (T/Li). There is no doubt that the reported data for sector output per worker may depart rather far from "real" productivity in this sector, which tends to be largely a government responsibility in most countries with "administered" prices and wages. This explains the search for non-monetary indicators although, given the heterogeneity of the sector, it has not been possible to find indicators covering the entire range of the sector's activities.

The results indicated in Table II-8 show that the non-monetary indicators do not improve the significance of the results as compared to

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* Source: World Energy Supplies, UNO, 1959-1962 and 1961-64; U.N. Statistical Yearbook 1964-65.

** Taken from Niewiaroski, op. cit., and the same sources as above.

Table II.7. ELECTRICITY, GAS AND WATER: REGRESSION EQUATIONS BETWEEN OCCUPATIONAL STRUCTURE (Lij/Li) AND ECONOMIC INDICATORS (n)

log (Lij/Li) = log a + b log (n)

	OUTPUT PER WORKER: Xi/Li				GROSS CAPITAL FORM, PER WORKER: Σ I/Li				ENERGY PRODUCTION PER WORKER: EP/Li				ENERGY CONSUMPTION PER CAPITA: E/P			
	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)
Major Groups:																
0	36	0.66*	1.06	0.51(0.09)	15	0.65*	1.89	0.63(0.21)	39	0.43*	0.41	0.15(0.05)	39	0.59*	1.58	0.30(0.07)
1	36	0.24	0.91	0.32(0.22)	15	0.54*	1.96	0.54(0.23)	39	0.28	0.09	0.15(0.09)	39	0.30	0.48	0.24(0.13)
0+1	36	0.61*	-0.48	0.39(0.09)	15	0.84*	1.12	0.49(0.09)	39	0.49*	0.58	0.14(0.04)	39	0.57*	0.15	0.25(0.06)
2	36	0.28	0.25	0.26(0.15)	15	0.20	1.67	0.10(0.14)	39	0.14	1.05	0.05(0.06)	39	0.27	0.71	0.15(0.09)
3	36	0.25	2.51	0.53(0.35)	15	0.10			39	0.40*	1.27	0.37(0.14)	39	0.27		
0+1+2+3	36	0.38*	0.50	0.25(0.11)	15	0.19			39	0.27			39	0.38*	0.93	0.16(0.06)
Minor Groups:																
0-0	17	0.46*	1.13	0.43(0.22)	10	0.52	1.91	0.56(0.33)	17	0.68*	0.39	0.36(0.10)	17	0.43	0.46	0.28(0.15)
0-1	17	0.26			10	0.33			19	0.49*	1.89	0.33(0.14)	19	0.52*	2.94	0.56(0.22)
0-X	17	0.52*	2.39	0.73(0.31)	10	0.41			17	0.26			17	0.41		
STP	22	0.59*	1.24	0.54(0.17)	12	0.59*	1.81	0.61(0.26)	24	0.65*	0.01	0.33(0.08)	24	0.64*	0.67	0.44(0.11)
0-02	13	0.65*	2.10	0.68(0.24)	9	0.39	0.34	0.20(0.18)	12	0.62*	0.37	0.33(0.14)	12	0.50	0.68	0.34(0.18)

Table II.8 TRANSPORT AND COMMUNICATIONS: REGRESSION EQUATIONS BETWEEN OCCUPATIONAL STRUCTURE (Lij/Li) AND ECONOMIC INDICATORS (n)

$$\log (Lij/Li) = \log a + b \log (n)$$

	OUTPUT PER WORKER: Xi/Li				COMMERCIAL VEHICLES PER WORKER: C/Li				NUMBER OF TELEPHONES PER WORKER: T/Li			
	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)
Major Groups:												
0	37	0.30	-1.13	0.38(0.21)	42	0.03			39	0.55*	-0.08	0.44(0.11)
1	36	0.52*	-1.61	0.58(0.16)	41	0.26			38	0.37*	0.20	0.26(0.10)
0+1	36	0.53*	-1.03	0.48(0.13)	41	0.13			38	0.49*	0.20	0.13(0.04)
2	36	0.26	0.41	0.19(0.12)	41	0.51*	1.14	0.26(0.07)	38	0.24		
3	36	0.31	-1.87	0.44(0.23)	41	0.39*	-0.28	0.37(0.14)	38	0.22		
0+1+2+3	36	0.39*	0.35	0.26(0.11)	41	0.43*	1.27	0.19(0.07)	39	0.35*		
6	33	-0.35*	2.21	-0.15(0.07)	38	-0.35*	1.70	-0.09(0.04)				
Minor Groups:												
STP	24	0.17			27	0.17			26	0.32		
0-02	16	0.30			17	0.06						
Occupational Coefficients:												
6/X	33	-0.94*	2.22	-1.15(0.07)								

the productivity variable. All correlation coefficients are low and many are non-significant; the standard deviations of the regression coefficients are high in all cases.

We have also included major group 6 - workers in transport and communications which constitute, of course, the bulk of employment in this sector. As could be expected, this occupational category is negatively correlated with the explanatory variables. Anticipating on Annex C, we have also expressed this category as an occupational coefficient (6/X) and, as can be seen in Table II-8 (last row) and Graph II-15, the relationship between this coefficient and sector productivity gives the only highly significant fit in this economic sector.

9. COMMERCE

The share of sector employment in commerce of the maximum of 44 countries for which we have the necessary data ranges from 3% in Zambia and Turkey to 22% in the United States in 1960. As already noted for the previous economic sector, rising levels of sector development imply a decrease in the proportion of "mainstay" or sector-specific workers and a rise in the proportion of higher qualified manpower categories. The "mainstay" group in the commerce sector being major group 3 (sales workers), it did not make much sense to retain the usual aggregate of non-manual worker (0 + 1 + 2 + 3) for the analysis. The STP minor groups have also been excluded because of their relative unimportance in this sector.

The explanatory variables adopted are sector productivity, gross capital formation per worker, and sector share of employment. In addition, GDP per capita has also been included for reasons already exposed in section 3 above.

In actual fact the productivity variable for this sector is more meaningful than for services, and this shows up in Table II-9, where it can be seen that the results with Xi/Li compare very well with those obtained with X/P. The "mainstay" occupational group (m. g. 3) is again negatively correlated with the economic and technological variables, as could be expected and as was the case with major group 6 in transport and communications. Graph II-16 depicts this relationship between the proportion of sales workers in the sector, on the one hand, and sector output per worker, on the other. The very flexible utilization pattern of the occupational structure is once again confirmed through this graphic presentation.

Of the four explanatory variables retained, $\Sigma I/L$ gives by far the highest correlation coefficients, although the standard errors are still rather formidable. The only rational explanation one can advance for this result lies in the much lower number of available observation.

The lower part of Table II-9 shows some of the dependent variables expressed in a different way: first, as so-called "mainstay" ratios with the sector-specific occupational group in the denominator*, and, second, as occupational coefficients with sector output in the denominator. The

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* Reasons for doing so can be found in C. Leicester, The Manpower Link between Economic Growth and Education, OECD, 1966, mimeographed (DAS/EID/66.5), pp. 23-24.

Graph II-15

TRANSPORT: WORKERS IN TRANSPORT OCCUPATIONS PER UNIT OF SECTOR OUTPUT (Lij/Xi)
AND SECTOR OUTPUT PER WORKER (Xi/Li)

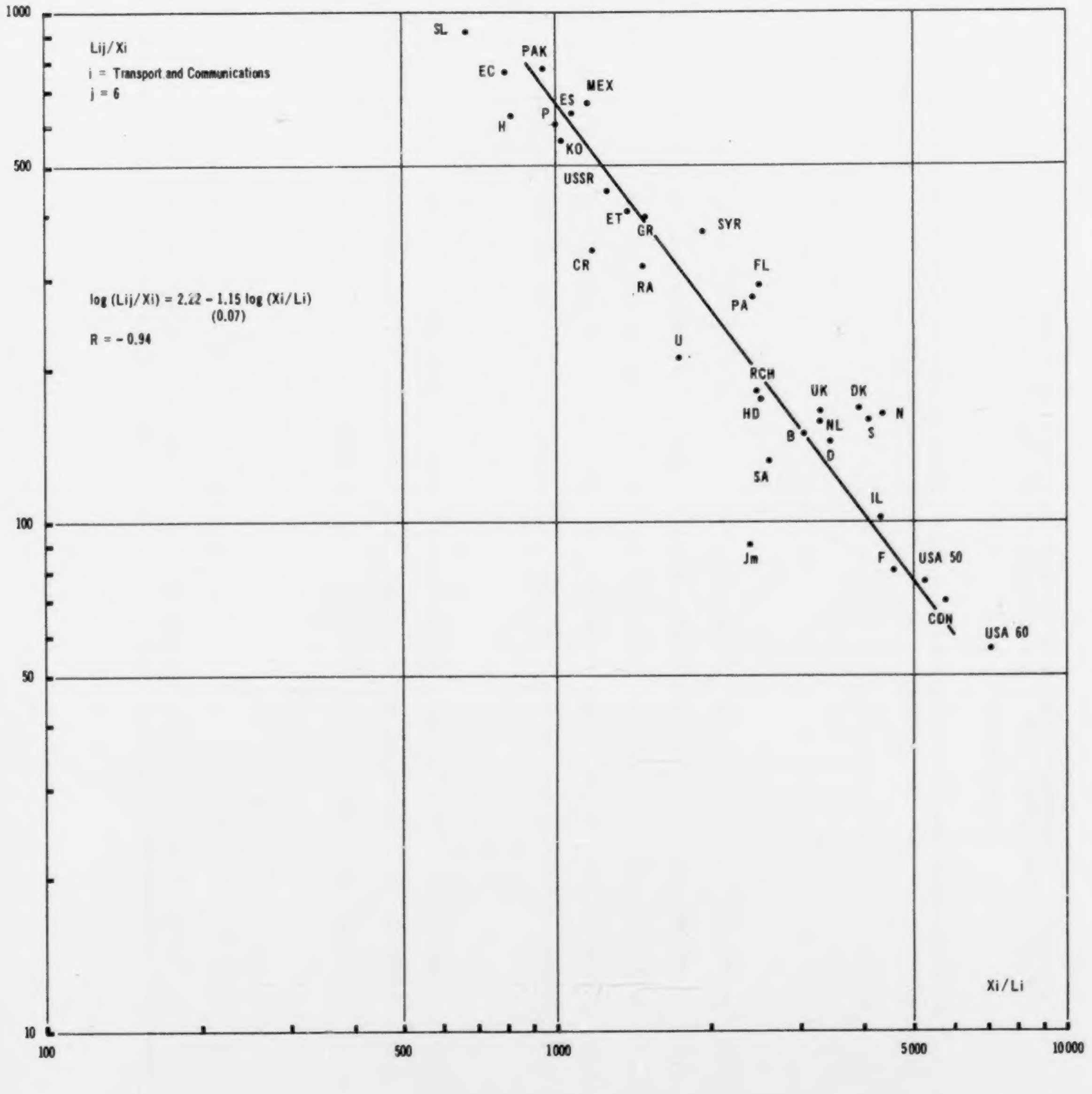


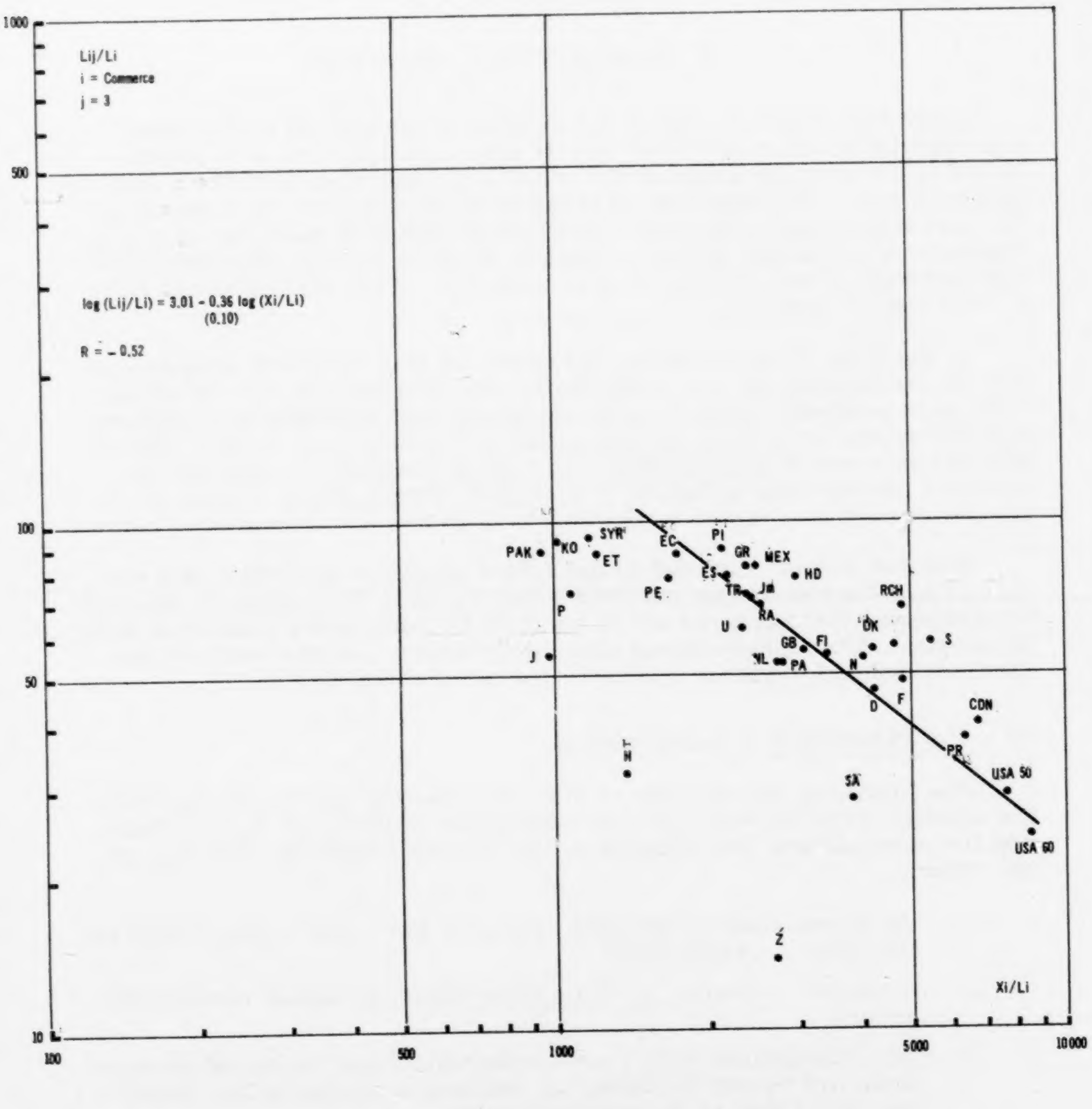
Table II-9. COMMERCE: SIMPLE REGRESSION EQUATIONS BETWEEN OCCUPATIONAL STRUCTURE (Lij/Li) AND ECONOMIC INDICATORS (n)

$$\log (Lij/Li) = \log a + b \log (n)$$

	OUTPUT PER WORKER: Xi/Li				GDP PER CAPITA: X/P				GROSS CAPITAL FORM. PER WORKER: Σ I/Li				SECTOR SHARE OF EMPLOYMENT: Li/L			
	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)
Major Groups:																
0	36	0.49*	-2.21	0.70(0.21)	44	0.47*	-1.21	0.51(0.15)	13	0.81*	-1.87	0.58(0.13)	43	0.10		
1	34	0.64*	-3.01	1.02(0.22)	42	0.47*	-0.80	0.48(0.14)	13	0.79*	-2.80	0.89(0.21)	42	0.39*	-0.38	0.86(0.33)
0+1	34	0.70*	-2.43	0.91(0.17)	42	0.51*	-0.58	0.47(0.12)	13	0.75*	-1.72	0.64(0.17)	42	0.37*	-0.03	0.70(0.29)
2	34	0.58*	-0.71	0.53(0.13)	42	0.61*	0.02	0.40(0.08)	13	0.77*	-0.67	0.50(0.12)	42	0.42*	0.49	0.60(0.20)
3	35	-0.52*	8.01	-0.36(0.10)	43	-0.46*	2.30	-0.20(0.06)	13	0.80*	2.78	-0.28(0.06)	43	-0.11		
Main-stay ratios:																
0/3	35	0.62*	-3.38	1.09(0.23)	43	0.51*	-1.45	0.68(0.18)	13	0.92*	-2.65	0.86(0.11)	42	0.16		
1/3	34	0.66*	-4.01	1.38(0.28)	42	0.50*	-1.09	0.68(0.19)	13	0.81*	-5.58	1.17(0.25)	41	0.32	-0.22	0.94(0.44)
2/3	34	0.63*	-1.71	0.89(0.20)	42	0.62*	-0.27	0.60(0.12)	13	0.85*	-3.45	0.78(0.15)	41	0.32	0.65	0.67(0.31)
Occupational Coefficients:																
2/X	34	-0.53*	1.29	-0.47(0.13)	34	-0.11			12	-0.28			34	-0.11		
3/X	35	-0.92*	5.01	-1.36(0.10)	35	-0.78*	2.30	-0.74(0.10)	13	-0.93*	3.92	-0.99(0.12)	33	-0.43*		

Graph II-16

COMMERCE: SALES WORKERS (Lij/Li)
AND SECTOR OUTPUT PER WORKER (Xi/Li)



introduction of "mainstay" ratios slightly improves the results, but the most interesting result is again obtained with the sector-specific occupational coefficient - L_3/X (last row of Table II-9).

10. A "HORIZONTAL" ANALYSIS

After this rapid survey of the results of the simple correlation and regression analyses by sector of economic activity, it is appropriate to summarize some of the results by looking at them in a slightly different way. The best way of doing this, seems to be by presenting the correlation and regression coefficients obtained with one or more explanatory variables across economic sectors so that inter-sectoral comparisons of the results become possible. This will be called here a "horizontal" analysis.

In the light of the evidence presented so far, this kind of analysis will be undertaken for the productivity variable only (X/L). It would have been perfectly feasible to do the same with the other explanatory variables used in most economic sectors (such as In or $\Sigma I/L$). Those who are interested in this additional type of analysis can find all the relevant information in Tables II-1 to II-9, which makes it possible to construct synthetic tables analogous to II-10 and II-11 presented below.

It is not without interest to unfold the analysis according to a series of hypotheses or assumptions which seem to be frequently adopted by manpower planners, or which seem to be built in the results of their forecasts. After enumerating those hypotheses, we can see how far the international evidence available confirms them or not.

i) The hypotheses or assumptions

The following hypotheses, it may be recalled, are concerned with the relationships between (sector) output per worker, on the one hand, and the occupational percentages in the various economic sectors, on the other:

1. the correlation coefficient is higher for major group 0 than for the other major groups;
2. however, within m. g. 0 the correlation is higher for the STP group;
3. the correlations with these professional and technical occupations are better in industrial sectors (manufacturing, electricity, etc.) than in the other sectors;
4. the correlations for m. g. 1, and particularly for major groups 2 and 3, will be lower than for the professional and technical groups;
5. the regression (elasticity) coefficients for m. g. 0 will be higher than for any of the other major groups. In other words, professional and technical personnel will grow faster with productive development than the other non-manual categories;
6. within major group 0, the STP groups grow faster, and within STP technicians (0-X), increase faster than engineers (minor group 0-0 or unit-group 0-02);

7. all these groups increase more rapidly in the industrial than in the other economic sectors;

8. major groups 1 and 2 (managerial and clerical workers) will grow at about the same pace relative to productivity increase, while m. g. 3 (sales workers) will increase more slowly.

ii) The results

The first four hypotheses concern the correlation coefficients of the various occupational groups within the same economic sector and of each of the groups across economic sectors. Table II-10 presents the relevant results. We will deal with the hypotheses in succession.

1. The first hypothesis cannot be rejected, except in transport and in commerce; in these two sectors, the managerial category comes out on top. In general, however, the proportion of professional and technical workers is indeed better correlated to the productivity variable than that of any other major group. However, the degree of dependence varies greatly from sector to sector: R varies from over 0.9 for the whole economy, *via* 0.8 in manufacturing, to 0.3 in transport.

2. The second hypothesis has to be rejected in the majority of cases in the light of the evidence. The correlation coefficient for the STP group as a whole is not significantly higher than for major group 0, except in the construction sector. Scientific and technical personnel, when taken alone, thus seems to be more losely related to the productive levels attained by countries in their respective economic sectors than when combined with the rest of the professional workers, such as medical practitioners, teachers, social scientists, etc. These latter occupations are usually thought to be more associated with general living standards than with standards of production. At this point, we have to recall the remark already made in Chapter III to the effect that many of our explanatory variables reflect both demand and supply effects.

Before going on to the next hypothesis, it is worth while examining for a moment the correlations with the various minor groups composing STP and, particularly, with the engineering categories. We have just seen that there seems to be a loss of information when going down from major group 0 as a whole to the STP level. However, the information flow increases again when proceeding to the more disaggregated engineering categories: this is the case for the whole economy, mining, manufacturing, services and, to a certain extent, for electricity. In spite of the increase, the correlation coefficient for m. g. 0 remains higher than for the "best" minor group, except in two cases.

3. The third hypothesis postulates a better correlation between productivity and major group 0 (and its minor groups) in the industrial than in the other sectors. Table II-10 clearly shows that the correlation coefficients for the professional and technical occupations are systematically higher at the level of the whole economy than at the sector level. If we compare strictly the sector results, the only sector for which the hypothesis cannot be rejected is manufacturing. The other industrial sectors have often lower correlation coefficients than either agriculture or services, which is due less to the goodness of fit in

Table II-10. "HORIZONTAL" ANALYSIS: CORRELATION COEFFICIENTS (R) AND NUMBER OF OBSERVATIONS (N) OF OCCUPATIONAL CATEGORIES WITH LABOUR PRODUCTIVITY

SECTOR	WHOLE ECONOMY		AGRICULTURE		MINING		MANUFACTURING		CONSTRUCTION		ELECTRICITY GAS AND WATER		TRANSPORT AND COMMU-NICATIONS		COMMERCE		SERVICES[1]	
	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R	N
Major Groups:																		
0	0,91*	43	0,67*	39	0,52*	35	0,80*	36	0,44*	41	0,66*	36	0,30	37	0,49*	36	0,53*	43
1	0,83*	42	0,61*	28	0,31	35	0,67*	35	0,28	39	0,24	36	0,52*	36	0,64*	34	0,43*	42
2	0,82*	42	0,40*	35	0,12	35	0,79*	35	0,45*	39	0,28	36	0,26	36	0,58*	34	0,26	42
3	0,20	42			-0,05	35	0,74*	35			0,25	36	0,31	36	-0,52*	35	0,13	43
0+1	0,93*	42	0,73*	28	0,58*	35	0,80*	35	0,58*	39	0,61*	36	0,53*	36	0,70*	34	0,57*	42
0+1+2+3	0,79*	42			0,26	35	0,82*	35*			0,38*	36	0,39*	36			0,58*	42
Minor Groups:																		
0-0	0,87*	24			0,61*	16	0,75*	16	0,32	21	0,46*	17					0,63*	20
0-1	0,79*	22			0,49*	22	0,13	18			0,26	17					0,41	20
0-2	0,53*	26	0,53*	19													0,25	23
0-X	0,53*	23	0,33	14	0,33	17	0,50*	16	0,29	19	0,52*	17					0,32	20
STP	0,79*	31	0,56*	25	0,54*	24	0,65*	22	0,51*	26	0,59*	22	0,17	24			0,56*	27
0-02	0,92*	16			0,44	15	0,80*	12	0,52*	17	0,65*	13	0,30	16			0,64*	15
1-1	0,73*	25															0,39	22

[1] GDP per capita.

SOURCE: See Tables II-1 to II-9.

these two sectors than to the very poor relationships in the other sectors.

4. The fourth hypothesis is related to the first one, but implies a hierarchy in the results as far as the correlations of the major groups are concerned. In general, this hypothesis cannot be rejected, although attention has to be drawn to the result for major groups 2 and 3 in the whole economy and in manufacturing.

Hypotheses 5 through 8 refer to the relative values of the regression coefficients. The relevant results are summarized in Table II-11.

5. The fifth hypothesis states that the regression (elasticity) coefficient of m. g. 0 is higher than those of the other major groups. If we neglect for a moment the standard deviations, this hypothesis is confirmed in four out of nine cases (counting the whole economy as a "sector"): mining, manufacturing, construction, and electricity, i. e., in all the industrial sectors. The difference is particularly evident in the manufacturing sector, although the elasticity of sales workers is astonishingly high. In the next chapter, this case will be further examined when we come to the problem of "deviant" cases. In agriculture, the professional and technical workers seem to increase in numbers at about the same rate as the managerial workers relative to productivity increases. In transport, commerce and services, the reverse picture emerges: the managerial category increases faster with rising levels of development. The same is true for the whole economy.

It will be obvious that a more subtle reasoning is required as soon as the standard deviations are taken into account, in particular, when they are relatively important.

6. This hypothesis refers to the more rapid expansion of STP within m. g. 0 and, within STP, to a quicker expansion of technicians as compared to the engineering occupations. The first part of the hypothesis cannot be rejected: the STP category has a higher elasticity coefficient in almost all sectors, except perhaps in agriculture and, certainly in transport and commerce, where these parameters cannot be significantly estimated. As already observed previously, the increased precision in terms of the occupational description is offset by a loss in precision in the regression coefficients.

The second part of the hypothesis is not supported by the limited evidence available. For the whole economy, the increase in the proportion of technicians is actually considerably slower than that of any other minor or unit group. The standard deviations are quite considerable throughout, however.

7. Hypothesis No. 7 postulates that the professional and technical categories increase faster in the industrial than in the other economic sectors. For m. g. 0 as a whole, the hypothesis is only confirmed for manufacturing; agriculture and commerce have higher elasticities than mining, construction and electricity. More or less analogous patterns hold for the STP categories.

8. The last hypothesis has to be rejected: the managerial group seems to increase faster than the clerical workers, whilst the sales workers show a very erratic pattern from one economic sector to another.

Tableau II-1'. "HORIZONTAL" ANALYSIS: REGRESSION COEFFICIENTS (AND STANDARD DEVIATION) OF OCCUPATIONAL CATEGORIES ON LABOUR PRODUCTIVITY

SECTOR	WHOLE ECONOMY	AGRICULTURE	MINING	MANUFACTURING	CONSTRUCTION	ELECTRICITY GAS AND WATER	TRANSPORT AND COMMUNICATIONS	COMMERCE	SERVICES[1]
Major Groups:									
0	0.66 (0.05)	0.83 (0.15)	0.60 (0.17)	1.00 (0.14)	0.54 (0.18)	0.51 (0.09)	0.38 (0.21)	0.70 (0.21)	0.18 (0.05)
1	0.92 (0.10)	0.85 (0.22)	0.43 (0.23)	0.59 (0.12)	0.46 (0.26)	0.32 (0.22)	0.58 (0.16)	1.02 (0.22)	0.28 (0.09)
2	0.71 (0.08)	0.51 (0.20)		0.65 (0.10)	0.42 (0.14)	0.26 (0.15)	0.19 (0.12)	0.53 (0.13)	
3	0.14 (0.11)			0.96 (0.17)		0.53 (0.35)	0.44 (0.23)	-0.36 (0.10)	
0+1	0.73 (0.05)	0.75 (0.14)	0.52 (0.13)	0.72 (0.10)	0.52 (0.12)	0.39 (0.09)	0.48 (0.13)	0.91 (0.17)	0.19 (0.05)
0+1+2+3	0.48 (0.06)		0.23 (0.13)	0.69 (0.09)		0.25 (0.11)	0.26 (0.11)		0.16 (0.04)
Minor Groups:									
0-0	1.06 (0.13)		0.53 (0.18)	1.39 (0.36)	0.42 (0.28)	0.43 (0.22)			0.61 (0.18)
0-1	1.21 (0.21)		1.10 (0.44)						0.47 (0.24)
0-2	0.89 (0.29)	0.82 (0.31)							
0-X	0.64 (0.22)		0.68 (0.50)	1.17 (0.54)	0.71 (0.57)	0.73 (0.31)			
STP	0.98 (0.14)	0.80 (0.25)	0.65 (0.21)	1.03 (0.43)	0.80 (0.28)	0.54 (0.17)			0.42 (0.12)
0-02	1.03 (0.16)		0.81 (0.46)	0.96 (0.25)	0.73 (0.31)	0.68 (0.24)			0.49 (0.16)
1-1	0.92 (0.18)								

1. GDP per capita.
SOURCE: See Tables II-1 to II-9.

VI

FURTHER OCCUPATIONAL ANALYSES

We shall now make a series of supplementary analyses dealing successively with multiple regression analysis, occupational analysis for a few sub-groups of manufacturing, adjusting for "deviant cases", and functions implying variable elasticity coefficients.

1. MULTIPLE REGRESSION ANALYSIS

The quantification of relationships between the occupational structure and indicators of development presented in the previous chapter was based on simple correlation and regression analysis. It is interesting to examine if the introduction of more than one explanatory variable improves the results so far obtained in any significant manner. In this respect, it is especially X/L and $\Sigma I/L$ which are worth considering. Table II-12 presents, for the whole economy, the results of the following equation:

$$\log (Lj/L) = \log a + b \log (X/L) + c \log (\Sigma I/L) \qquad (7.1)$$

The outcome of these calculations is disappointing, owing mainly to the high intercorrelation between X/L and $\Sigma I/L$. This causes the resulting regression coefficients to become non-significant. One example will suffice: for minor group 0-0, at the level of the whole economy, the following simple regression equation was calculated with $\Sigma I/L$ as the explanatory variable (see Table II-1):

$$\log (Lo\text{-}o/L) = -2.78 + \underset{(0.22)}{0.78} \log (\Sigma I/L) \qquad \begin{array}{l} R = 0.70 \\ N = 15 \end{array} \qquad (7.2)$$

Adding X/L to the equation and using the same country observations, the results are as follows:

$$\log (Lo\text{-}o/L) = -4.04 + \underset{(0.62)}{1.44} \log (X/L) - \underset{(0.49)}{0.29} \log (\Sigma I/L) \qquad \begin{array}{l} R = 0.80 \\ N = 15 \end{array} \qquad (7.3)$$

By adding X/L, the correlation coefficient has gone up from 0.7 to 0.8. This, however, has been obtained at the expense of a severe loss in the significance of the regression coefficients. Moreover, Table II-1 reminds us of the fact that the results with X/L alone were much better in all respects than those of equations (7.2) and (7.3). *

The only interesting aspect of equation (7.3) is the suggestion of the possibility of substitution between capital and engineers (cf. the negative regression coefficient for $\Sigma I/L$), but the large standard error attached to the regression coefficient makes even this aspect highly dubious.

Table II-12 indicates that the problem of the size of the standard errors is a general one; only in one case, the combined 0 + 1 category, could both regression coefficients be considered as significant. Attempts with a step-wise regression programme at the level of the whole economy and in the various economic sectors confirm the above results: once the "best" independent variable has been selected, the addition of further explanatory variables hardly increases the correlation, and the regression coefficients usually become insignificant.

One final point may be worth mentioning. It can be assumed a priori that, for the smaller economic sectors, the introduction into a multiple regression equation of the scale variables would improve the results of the fit. As an illustration, we present some of the results for the mining sector, relating the professional and technical categories to sector output per worker (Xi/Li) and sector share of output (Xi/X).

- Major group 0:

$$\log (Lo/Li) = -1.35 + \underset{(0.18)}{0.49} \log (Xi/Li) + \underset{(0.11)}{0.22} \log (Xi/X) \qquad \begin{array}{l} R = 0.60 \\ N = 31 \end{array} \qquad (7.4)$$

- Minor group 0-0:

$$\log (Lo\text{-}o/Li) = -1.35 + \underset{(0.18)}{0.38} \log (Xi/Li) + \underset{(0.10)}{0.28} \log (Xi/X) \qquad \begin{array}{l} R = 0.78 \\ N = 14 \end{array} \qquad (7.5)$$

- STP

$$\log (L_{STP}/Li) = -1.62 + \underset{(0.22)}{0.52} \log (Xi/Li) + \underset{(0.12)}{0.24} \log (Xi/X) \qquad \begin{array}{l} R = 0.67 \\ N = 21 \end{array} \qquad (7.6)$$

When comparing these results with the simple regressions (see Table II-5), it will be noted that, for an approximately similar number of observations, adding the size variable to the productivity variable increases the correlation coefficients considerably. The regression coefficients are not very clear, however, particularly those of the size variables.

If we are, therefore, entitled to say that the size of this sector seems to have some influence on the share of professional workers and, particularly, on the share of the STP and engineering categories, this

* R = 0.87; b = 1.06 (0.13) with 24 observations.

Table II-12. WHOLE ECONOMY: MULTIPLE REGRESSION EQUATIONS BETWEEN OCCUPATIONAL STRUCTURE (Lj/L), OUTPUT PER WORKER (X/L) AND GROSS CAPITAL FORMATION PER WORKER (ΣI/L)

$$\log (L_j/L) = \log a + b \log (X/L) + c \log (\Sigma I/L)$$

	N	R	log a	b(σ b)	c(σ c)
Major Groups:					
0	28	0.93	-1.02	0.15 (0.13)	0.41 (0.10)
1	27	0.77	-2.19	0.58 (0.33)	0.19 (0.26)
0+1	27	0.94	-1.06	0.25 (0.12)	0.36 (0.10)
2	27	0.77	-0.90	0.31 (0.24)	0.23 (0.19)
3					
0+1+2+3	27	0.84	0.04	0.12 (0.16)	0.29 (0.12)
Minor Groups:					
0-0	15	0.80	-4.04	1.44 (0.62)	-0.29 (0.49)
0-X	14	0.63	-2.44	-0.14 (0.72)	0.83 (0.59)
0-0+0-X	19	0.80	-3.90	0.78 (0.59)	0.42 (0.48)
STP	19	0.78	-3.15	0.63 (0.54)	0.38 (0.44)
1-1	17	0.66	-2.27	0.72 (0.68)	0.04 (0.54)

does not seem to be the case for the managerial and clerical groups. Thus the multiple correlation coefficients of major groups 1, and particularly 2, with Xi/Li and Xi/X are barely higher than those with sector productivity alone.

In spite of a few more or less interesting exceptions, the conclusion of this section is clear: in general, the different explanatory variables selected cannot fruitfully be combined in a multiple regression equation. Simple regression analysis has to be adhered to.

2. OCCUPATIONAL ANALYSIS FOR SUB-GROUPS OF MANUFACTURING

One of the results of the analysis presented in the previous chapter has been that the relationships found between the occupational structure, on the one hand, and the economic indicators, on the other, are more systematic and more reliable at the macro-economic level than at the sector level. In other words, sector disaggregation actually makes for poorer results.* An attempts has been made to examine whether this trend is confirmed at the sub-sector level. The occupational data available from our source** did not permit covering more than two two-digit branches in manufacturing: chemical industries (ISIC 31-32) and basic metals and metal products (ISIC 34-38). The number of observations is 13 at most. For this reason, no statistical estimates were attempted. Graphic analysis has shown, however, that such estimates would probably have yielded very poor results.

Thus, the proportion of managerial workers in the chemical industries, for example, varies from single to double as between Germany and Great Britain, apparently at a similar productivity level, while Argentina (with one-fifth of that productivity) reports the same proportion as Great Britain. For minor group 0-0, an asymptotic relationship to productivity is suggested, with the proportion of engineers remaining stable at productivity levels above 6,000 dollars.

For the broader sector metal manufacturing, similarly vague relationships appear for managers and, particularly, professional and technical workers. One of the explanations for the poor fit in these sub-sectors could lie in the "choice" of countries which are, with two exceptions, all more or less highly industrialized. As can be seen in many of the graphs shown in Chapter V, the link between occupational structure and productivity is usually (but not always) rather loose at the higher levels of economic development. More detailed analysis, on the basis of more abundant data, will be necessary before any definite conclusions can be drawn from this sub-sector analysis.

3. CORRECTING FOR "DEVIANT CASES"

The calculations presented in Chapter V made use of the maximum number of available observations. An attempt will now be made to identify these observations which can be considered to disturb the "true" relationship between the variables for one or several of the following reasons: (i) probable errors in classifying the dependent variable (clerical workers classified in the managerial category, technicians among engineers or vice versa), having assumed, however, that the probability of such errors was not great enough to justify the exclusion of such observations from the outset; (ii) errors in measuring either the dependent or the independent variable. Examples may be found in the ambiguities of estimating agricultural production or employment; the definition of sector output (e.g., countries giving net material or domestic product only); the conversion at official exchange rates; the definition of the active population (the exclusion or not of female workers, domestic workers, first job seekers, etc.); and (iii) observations which clearly deviate from the basic pattern because of certain atypical events, such as policies of rapid industrialization with a consequent bias in the occupational structure; position of dependence, e.g., in trade, with consequent concentration on certain occupations, etc.

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* Althought account will have to be taken of the improved results when correcting for deviant cases, as will be shown in the following section.

** Statistics on the Occupational and Educational Structure .... in 53 countries, op. cit.

The search for deviations due to any of these three reasons obviously implies personal judgment in each case. This is particularly true for observations of the third type. It may not be superfluous to add that observations which were more or less deviant from the regression line were not excluded without this being explained by one or more of the above reasons. For certain countries we did, however, exclude an observation which, without being deviant (as far as was known) in any of the three senses understood above, could still be suspected to bias the regression results by its extreme position in relation to the other observations so as to "stretch out" the correlation or make for a higher regression coefficient than seemed justified by the "normal" average among countries.

As far as possible, we have tried to make explicit the reasons underlying the elimination of each observation concerned.

i) The Whole Economy

It will be recalled that the best results of the regression analysis carried out so far have been obtained at the level of the whole economy and with output per worker as the independent variable. A special effort was called for here to make these results as applicable as possible for forecasting purposes.

As to the equation relating professional and technical workers to output per worker, the following seven countries were excluded: the four East European socialist countries, Finland, Israel and South Africa.* The results of the regression analysis changed very little: the correlation coefficient increased to 0.91 with an unchanged regression coefficient ($b = 0.66$ and $\sigma = 0.04$).

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* Socialist countries, because of output definition; Finland, because of probable inclusion of "foremen" in m. g. 0; Israel, because of the third reason, and South Africa, because of the labour force definition.

The same is true with regard to the managerial category. Eliminating five countries, all different from the seven above*, increased the correlation coefficient very little and gave about the same elasticity: 0.94 (0.08). In spite of the extreme position of some of these countries (see Graph II-2), their weight is apparently not important enough to change the basic relationship. The proportion of managerial workers definitely tends to increase more rapidly than that of professional and technical workers, contrary to our expectations as discussed in the previous chapter.

For the HLM group as a whole (0 + 1), all thirteen countries mentioned above were excluded. Again, this barely increased the correlation coefficient and left the elasticity almost unchanged: 0.75 (0.04).

More interesting results are obtained with the minor groups. In the case of the STP and engineering categories, the following countries excluded were: Germany (ambiguous around the Ingenieur-Schulen), the socialist countries (see above), and Jamaica (classification errors). In the case of the STP category, Finland was also excluded for the reasons stated above.

The results of the recalculation are as follows:-

$$\log (L_{o\text{-}o}/L) = -3.42 + \underset{(0.08)}{0.96} \log (X/L) \qquad R = 0.95,\ N = 18 \qquad (7.7)$$

$$\log (L_{STP}/L) = -2.90 + \underset{(0.11)}{0.91} \log (X/L) \qquad R = 0.88,\ N = 24 \qquad (7.8)$$

The log-linear relationship between minor group 0-0 and X/L now gives a correlation coefficient of 0.95 instead of 0.87, as shown in Table II-1; the b coefficient becomes 0.96 (0.08) instead of 1.06 (0.13). For the STP group, the correlation coefficient increases from 0.79 to 0.88, whereas the regression does not change significantly: 0.91 (0.11) instead of 0.98 (0.14).

The technicians' category (0-X) has also been recalculated with various countries excluded. However, the conclusions arrived at in Chapter VI remain valid: the growth of the engineering group proportion is more rapid than that of technicians, whatever the composition of the sample, and the standard deviations remain high.

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* All eliminations were done because of possible classification errors with regard to professionals, on the one hand, and to clerical workers, on the other.

Puerto Rico would have more managers than each of the two other major groups (in all other countries, the order is the reverse). As in several other sectors, Jamaica and Hong Kong also appear to have oddly high proportions (which may, however, be explained for the latter by the presence of many foreign managers, i.e., by a combination of causes (i) and (iii) as above).

Ecuador, El Salvador and Zambia all have very low proportions, the explanation for which has still to be found. Only Ecuador was excluded, since it may be responsible, with Puerto Rico at the other end, for the high elasticity. For France, however, the error appears to be a result of misclassification.

There are several other (rather less) aberrant cases (such as Panama, Korea and the United States 1960 with "too high" proportions, and Sweden and Ireland with low proportions). However, we had no particular reasons to treat these countries separately.

The Soviet bloc has in no way a special position. Excluding the four countries would do nothing to the regression.

Lastly, we tried to improve the results of the "substitution function" (see results of the multiple regression analysis with X/L and $\Sigma I/L$ as independent variables: Table II-12). The crucial problem of the statistical significance of the regression coefficients was not solved (the intercorrelation between X/L and $\Sigma I/L$ remained very high at around 0.90), although the multiple correlation coefficients increased quite considerably.

ii) Manufacturing

A recalculation of the professional and technical personnel category (with N = 27) with regard to sector productivity confirmed the unitarity elasticity found in the original results (Table II-2); the b coefficient now becomes 1.06 (0.11) and R increases from 0.80 to 0.89. The intercept (log a) falls to -3.16.

With regard to sales workers, it will be recalled that a relatively high R was found, but that the b coefficient looked suspiciously high (0.96). In the "corrected" version, the regression coefficient becomes 0.64 (0.16) and R also decreases, from 0.74 to 0.61 (for N = 27). Log a becomes - 1.88.

In the case of technicians, the elimination of only two countries (Hungary and Jamaica) increased the correlation coefficient from 0.50 to 0.60, but hardly changed the precision of the elasticity: 1.21 (0.46) instead of 1.17 (0.54).

An interesting result was obtained for the STP group. With 18 observations, the correlation coefficient increased from 0.65 to 0.85, whereas the regression coefficient became more precise: 1.15 (0.17) instead of 1.03 (0.43). The intercept fell to -3.62.

Lastly, it may be mentioned that the inclusion of two additional observations (Greece and the UAR) in the engineering category (0-02) slightly increased both the correlation and the regression coefficients: R = 0.83; b = 1.13 (0.24); -3.99 for 12 country observations.

iii) Other Economic Sectors

In agriculture and in electricity, correcting for deviant cases did not change the original results significantly. Even though in many cases the standard deviations become relatively smaller, they remained quite important on the whole.

In the mining sector, and still in relation to sector productivity, the "corrections" increased substantially the correlation coefficients, leaving the regression coefficients basically unchanged, though more precise.

A striking result was obtained through the exclusion of Germany in a multiple regression (including, next to Xi/Li, the scale variable Xi/X) for the two-digit engineering category (0-0).*

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* Germany reported a log-residual of + 0.56, probably as a result of the inclusion of "middle level" engineers.

$$\log(L_{o\text{-}o}/Li) = -1.45 + \underset{(0.10)}{0.40}\log(Xi/Li) + \underset{(0.06)}{0.25}\log(Xi/X) \qquad \begin{matrix} R = 0.92 \\ N = 13 \end{matrix} \qquad (7.9)$$

By the entirely justified exclusion of one country, this equation improved considerably as compared to equation (7.5) above. For the STP group, the improvement is less spectacular when Germany and Finland are excluded:

$$\log(L_{STP}/Li) = -1.54 + \underset{(0.17)}{0.48}\log(Xi/Li) + \underset{(0.09)}{0.28}\log(Xi/X) \qquad \begin{matrix} R = 0.79 \\ N = 19 \end{matrix} \qquad (7.10)$$

This equation is to be compared to (7.6) above.

*

* *

Many of the illustrations presented above show that a careful correction for so-called deviant cases can be successful, particularly for the minor groups, in improving the precision of the estimate.

4. FUNCTIONS WITH VARIABLE ELASTICITY

The preceding analysis was based entirely on an assumption of constant elasticities implicit in the adoption of a log-linear relationship between the variables. It may be argued that it is unrealistic to assume such an unchanging geometric relationship, particularly over long periods of time, and that a semi-logarithmic function, for example, would be more appropriate to depict the true relative development between the variables. A non-linear trend may also be caught by fitting a parabolic function. When it is felt that there is an upper limit to the growth of certain occupational shares, an asymptote would take account of it. The plain linear arithmetic function might, of course, also be tried, if one sees any reason for doing so. *

The trial calculations - made at the level of the whole economy only and considered appropriate in those instances - did not give significantly better results than the log-linear relationship. In fact, in most cases the results obtained were worse in terms of the value of the correlation coefficients and the significance of the regression coefficients.

A few illustrations may be helpful. In all cases, output per worker has been taken as the independent variable. **

i) Parabolic functions

The parabolic function makes Lj/L a function of X/L and of its square $(X/L)^2$. It has been tested rather more successfully than any of the other functions for professional and technical workers and for the STP category. The results are as follows:-

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* This function has been tried out by Layard (op. cit., p. 225); it gave consistently poorer results than the log-linear relationship.

** All equations were tested without the deviant cases, as reviewed in the previous section.

$$\log (Lo/L) = -4.48 + \underset{(0.58)}{2.67} \log (X/L) - \underset{(0.09)}{0.32} [\log (X/L)]^2 \qquad \begin{matrix} R = 0.96 \\ N = 36 \end{matrix} \quad (7.11)$$

$$\log (L_{STP}/L) = 5.05 + \underset{(1.93)}{2.28} \log (X/L) - \underset{(0.30)}{0.21} [\log (X/L)]^2 \qquad \begin{matrix} R = 0.87 \\ N = 25 \end{matrix} \quad (7.12)$$

Although the correlation coefficients, particularly for m. g. 0, are quite impressive, the obvious colinearity between labour productivity and its square makes interpretation difficult. It would not seem, therefore, that the marginal gains in the value of R counter balance the loss in ready interpretability and applicability as compared with the double-log function.

ii) Semi-logarithmic functions

The relationship log (Lj/L) = a + b (X/L) gives less reliable results than the double-log function in the three cases where this calculation was performed (m. g. 0, 1 and minor group 0-X).

The only result worth presenting concerns the technicians category:

$$\log (Lo\text{-}x/L) = -0.67 + \underset{(0.00008)}{0.00025} (X/L) \qquad \begin{matrix} R = 0.59 \\ N = 21 \end{matrix} \quad (7.13)$$

As compared to the results presented in Table II-1, the two United States observations have been excluded here, and the results are more or less comparable with the double-log equation calculated with the same country observations.

iii) Asymptotic functions

This function has been tried out for the total non-manual category (major groups 0 + 1 + 2 + 3) to see whether there is an upper limit to the proportion of "white collars" an economy can absorb. With the observations at our disposal, this question cannot be answered statistically with any degree of precision. For the equation Lj/L = a - b (1/X/L), the correlation coefficient is -0.66 (as compared with 0.79 in double-log form; same observations, see Table II-1). The asymptote, a, is close to 30%* and the regression coefficient, b, is -7781.7 (1349.9), i.e., much less precise than the log elasticity.

iv) Linear functions

The equation Lj/L = a + b (X/L) has been tried for three major groups and for the STP category. In all cases, the results were less reliable than with the double-log function. For major group 0, the result was:

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* This is the least quare value of the asymptote. Some countries have actually a proportion of non-manual workers exceeding this percentage (United States: 38%, Canada: 36%, etc.). Imposing a theoretical upper limit of, say, 50% might give better results. However, such a test, as also the present one, would be of analytical interest only, since no developing country comes near such a proportion.

$$\underset{}{Lo/L = 2.55 + \underset{(0.00014)}{0.00157}\ (X/L)} \qquad \begin{matrix} R = 0.89 \\ N = 36 \end{matrix} \qquad (7.14)$$

and for the STP category:

$$L_{STP}/L = 0.42 + \underset{(0.00008)}{0.00045}\ (X/L) \qquad \begin{matrix} R = 0.78 \\ N = 25 \end{matrix} \qquad (7.15)$$

VII

MAIN CONCLUSIONS

The preceding analysis of the occupational structure of the labour force suggests the following general conclusions:

- Output per worker and product per capita are, across the board, the best explanatory variables with regard to the occupational structure included in the analysis. In particular, the non-monetary indicators are, on the whole, not better related to the occupational structure than is X/L.
- The introduction of additional explanatory variables into the regression equation, although frequently improving the correlation coefficient, makes the estimate highly indeterminate because of the high standard deviations, caused in turn by the high intercorrelation between most of the independent variables. A few interesting exceptions were noted. In general, however, the results of the multiple regressions do not permit the rejection of the complementarity hypothesis between physical and highly-qualified human capital.
- The best overall results have been obtained for the whole economy, in terms both of correlation coefficients and of the significance of the regression coefficients. These results can even be improved upon by a careful correction for "deviant" countries. At the least, therefore, the international comparison approach could serve as a useful macro-economic checking device of national manpower estimates.
- The results for manufacturing, particularly after correcting for "deviant" cases, are also hopeful, although the problem of the high standard errors of the regression coefficients begins to loom large.
- In the other economic sectors, the occupational structures appear to be much more "flexible". This is particularly true in services and construction.
- Within the range of levels of development of the countries under review, it would appear that the log-linear (constant elasticity) function performs best.
- In general, it is the professional and technical personnel category (m. g. 0) which is best correlated to the independent variables. The engineering categories (at the two and three-digit level) frequently also give very good results. The STP categories have a tendency to increase faster than all other occupational categories as development proceeds.

- There is no doubt, however, that even if the regression results are fairly good, one can still observe different values for the occupational percentages within rather narrow productivity ranges (cf. Graph II-1). This is, of course, even more so in other cases, where the standard deviations are more important. Other factors could, of course, explain the observed variations: classification and definition problems (for example, technicians *versus* engineers), differences in the output composition of the sectors, etc.

However, the evidence strongly suggests significant differences in the utilization pattern of highly qualified personnel among countries. Quite clearly, at the level of aggregation of this study and with the kind of data used, any interpretation has to be made with extreme care. The analysis will have to be pursued on a case study basis by taking, for example, the countries with different occupational values and which are at analogous levels of development, and for by bringing in a host of additional explanatory variables in order to determine which are the most important factors behind those variations.

Part Three

ANALYSIS OF RELATIONSHIPS BETWEEN OCCUPATIONAL CATEGORIES, LEVELS OF EDUCATION AND SOME GENERAL ECONOMIC INDICATORS

The second part of this study dealt with the econometric relationships between the occupational structure of employment (as a whole and by sectors) and the general economic indicators. An additional dimension will now be introduced into the analysis, namely, the levels of education attained by the different occupational categories or the total labour force. On the other hand, the disaggregation by economic sectors will be neglected for the time being, as very few countries are able to supply data on the labour force broken down simultaneously by economic sectors, occupational categories and levels of education. Accordingly, we shall direct our attention to the occupational categories/levels of education matrices based on the total labour force.

The following table is included as a reminder of the general form of the matrices and the symbols most often used: j will represent, as before, occupational categories and k levels of education.

Levels of education Occupational categories	A	B...	k...	Total
1	L_{1A}	$L_{1B}\cdots$	$L_{1k}\cdots$	L_1
2	L_{2A}	$L_{2B}\cdots$	$L_{2k}\cdots$	L_2
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
j	L_{jA}	L_{jB}	L_{jk}	L_j
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
Total	L_A	L_B	L_k	L Total employment

The laborious task of preparing the matrices, involved finding a common classification both for occupational categories and for levels of education. The ISCO provided a common framework for the former;

for levels of education, a common *ad hoc* five-tier classification was worked out:

A: university degree level or above;

B: completed secondary level or above;

C: more than eight years' schooling;

D: eight years' schooling or less;

E: mean years of schooling.

Unfortunately, the available data did not permit to build this common educational classification for each of the occupational groups analysed in Part Two. Only the major groups and two minor groups of the ISCO were considered, namely: Major Group 0, professional and technical workers; major group 1, executive and managerial personnel; major group 2, clerical workers; major group 3, sales workers; major group 7/8, craftsmen and production workers; minor group 00+01+02+0X, scientific and technical personnel; minor group 0X, technicians. In addition, whenever the mean years of schooling is used to assess the educational inputs, major group 4, farmers, and major group 5, all manual categories except farmers*, were also analysed.

All the preparatory statistical work is explained at length in Annex A; numerical values of observations will be found in Annex G.

The relationships between the magnitudes included in the matrices and the general economic indicators, and between the magnitudes themselves, will be investigated by using simple and multiple regression analyses and the step-wise regression system. In all cases, a double-logarithmic function of the following type has been adopted:

$$\log y = \log a + b \log x \; (+ \; c \log z)$$

These relationships are classified in three main groups:

1. First, we try to test our initial assumption, i. e., to detect some significant econometric link between the level of education of the different occupational categories and the level of development. The latter will be measured by taking as a yardstick, first, some of the usual economic indicators, and secondly, the occupational structure of the labour force, which is itself largely a function of the same indicators, as shown in Part Two, at least on the level of the economy as a whole.

2. Commonsense would also suggest that the level of education in the different occupations largely depends on the total stock of education in the labour force. We shall, therefore, try to discover the connections between these two magnitudes, in order to draw up a "deployment model" of the total numbers at each level of education in the different occupational categories. The *independent* impact of the available stock of education embodied in the labour force on educational perfiles of occupations, will be called "educational supply effects".

3. The analyses mentioned in 1 and 2 will then be combined: this means that both the development indicators (economic variables and occupational structure of employment in turn), and the educational structure of the labour force will be introduced into a multiple regression equation. An attempt will therefore be made to measure the combined influence of the economic "needs" and of the "pressure" of the educational system on the educational profile of the different occupations.

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* This occupational grouping was called "major group 5" for the sake of commodity. It has nothing to do with major group 5 (miners) of the ISCO.

VIII

PRESENTATION OF THE ANALYSIS

1. INTRODUCTION

It may be well to point out that our aim here is to confirm what isolated comparisons or ordinary commonsense seem to suggest - that there is a certain positive correlation between the educational inputs incorporated in the labour force and certain economic variables indicating a given level of development. In other words, the most highly developed countries should have the most highly educated labour force, and *vice versa*.

While the analyses of spatial regression will enable us to confirm the existence of a correlation (more or less close, according to the case) between levels of education and levels of development, they cannot throw any light on the causal *relationship*: whatever indicator may be used to measure the level of development, does it result from the level of education of the working population, or is this level of education a consequence of the level of development attained ?

By and large, it can be said that all attempts to measure the contribution of education to economic growth consider the former as one significant cause of the latter in a production function; Denison's survey* broke new ground in this field, and has already made some converts.** On the other hand, all those whose job is to make systematic forecasts of educational needs as part of general economic planning calculate independent demand functions in which the explanatory variables are often the same as the dependent variables in the production function [or other closely correlated variables, which comes to the same thing].*** The wheel thus comes full circle; clearer evidence could hardly be found for the probability of a reciprocal causality.

This being granted, the investigator's realization of his inability to draw a clear line between cause and effect should not obscure the importance of clarifying the relationships in either direction by using all the statistical data available on the same lines as in the previous part of this study.[*]

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* See: *The Sources of Growth in the United States and the Alternatives before us.* New-York Committee for Economic Development, Supplementary Paper No. 13, 1962.

** *The Contribution of Education to Economic Growth* by G.W. Bertram. Economic Council of Canada, June 1966.

*** See Layard and Saigal, *op. cit.*, pp. 224 and 225, who are very explicit on this point, June 1966.

2. CHOICE OF VARIABLES

i) Dependent Variables

The level of education of the different occupational categories can be satisfactorily represented by the real numbers in category j who have reached each of the levels of education k, given Ljk (see matrix).

It is clear, however, that one cause of the variations in Ljk will be the size of the total force in the occupational category Lj, which suggests the idea of calculating the ratios Ljk/Lj in order to eliminate the dimensional effects. This percentage of each occupational category with a level of education k was, in fact, adopted as a dependent variable by Layard and Saigal in their study.

Their published findings show that the labour productivity variable used by them accounts for only a minute proportion of the variance observed in Ljk/Lj: the coefficients of determination (R^2) obtained are in most cases fairly small. A second rather less "refined" dependent variable had, therefore, to be found, while retaining the essence of the information supplied, i.e., Ljk. Thus a second dependent variable was chosen, Ljk/L, which affords the three-fold advantage of:

1. Taking account of the dimensional effects, owing to L;
2. completely separating the variations in Ljk from those in Lj, thus retaining only the proportion of group j with a level k in total employment;
3. lastly, providing the same information as Ljk/Lj.

It may further be noted that it is the educational structure of the total labour force, Lk/L, which ultimately interests the forecaster; the roundabout path through the various occupational categories is but an added luxury, since for each level of education k we have:

$$L_1k/L + L_2k/L + \ldots . \; Ljk/L + \ldots = \Sigma Ljk/L = Lk/L$$

(column totals in the Occupational categories/levels of Education matrix).

We shall, therefore, test this assumption, which is implicit in a number of studies on these question[**], by retaining also Lk/L as a dependent variable. The systematic comparison of equations taking Lk/L and Ljk/L in turn as the dependent variable will make it possible to ascertain the j categories able to provide a better fit than by using the level of education k alone.

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[*] Production function equations with labour input broken down by education levels as explanatory variables, will be presented in Annex D.

[**] E.g. Econometric Models of Education by Tinbergen and Bos, OECD Paris, 1965, and The Educational Structure of the Labour Force, Netherlands Economic Institute, Rotterdam, March, 1966, especially Chapter 3.

The occupational structure denoted by Lj/L has again been tested here, although in much less detail than in Part Two, with the object of comparing the fits obtained with Lj/L and Ljk/L for samples including the same number of observations.

Lastly, it might be interesting to consider a synthetic measure summarizing the total quantity of education embodied in each occupational category (kj) or in the total labour force (kt) after having analysed their successive levels of educational attainment. This will give us two more dependent variables.

To sum up, we shall take six dependent variables:

Ljk/Lj,	i.e., the numbers in a category j with an education k as a proportion of the total numbers in that category;
Ljk/L,	i.e., the numbers in a category j with an education k as a proportion of the total labour force;
Lk/L,	i.e., the total numbers with an education k as a proportion of the total labour force;
Lj/L,	i.e., the total numbers in a category j as a proportion of the total labour force;
k_j	representing the mean years of schooling for category j;
k_t	representing the mean years of schooling for the total active population.

ii) Explanatory Variables

Our technological indicators will be, in turn, labour productivity measured by value added per man-year (X/L), Niewiaroski's "economic" index (Ie), and the capital/labour ratio measured by the sum of gross fixed asset formation during the eight years preceding the census as related to total employment ($\Sigma I/L$).

The value and limitations of these variables have already been discussed in Part Two*; there is no need to go over the same ground again.

The occupational structure of employment (Lj/L) has also been used to try to "explain" the level of education of the various occupational categories. Part Two showed, in fact, that most of the variance in Lj/L can be "explained" by the economic indicators mentioned. We have, therefore, felt justified in considering the problem of variations in the occupational structure as being solved for the purpose of studying educational levels, thus adopting a two-phase procedure. **

As observed in the introduction to this part of the study, the total stock of education available in the labour force (Lk/L) should have an impact on the level of education of the different occupational categories. The educational structure of the labour-force will therefore be considered here as an explanatory variable of Ljk/L. ***

* See page 47 et seq.

** It will be noted that the occupational structure will be considered successively as a dependent variable and as an explanatory variable.

*** It will be noted that the educational structure is also used successively as a dependent variable and as an explanatory variable.

3. EQUATIONS

All the equations set out below are in double-logarithmic form. Each can, therefore, be characterized by the number of observations (N), the simple or multiple correlation coefficient (R), the constant (log a) and the different regression coefficients (b, c ...), each accompanied by its standard deviation.

i) Levels of education of the different occupational categories, technological indicators and the occupational structure of employment

Let n represent the three technological indicators, successively X/L, Ie and ΣI/L. A first serie of simple regression equations, linking the educational profile of the various occupational categories with the technological indicators, was tested:

$Ljk/Lj = f(n)$ See the results in Table III-1 and the comments in Chapter IX.

Then the level of education of the various occupational categories was linked with the technological indicators in an analogous way,

$$Ljk/L = f(n)$$

This series of equations was compared successively with the two following series:

$$Lj/L = f(n)$$

and

$$Lk/L = f(n)$$

The results are presented in Table III-2 and commented in Chapter X.

All the above equations were tested for each occupational group (from 5 to 9 categories as the case may be), associated in turn with each of the four levels of education A, B, C and D (cumulative measurements).

The overall level of education for each occupational group or for the total labour force was also tested, using the following equations:

$$k_j = f(n)$$

$$k_t = f(n)$$

See results in Table III-3 and comments in Chapter X.

At last, for each occupational category (j) associated with a level of education (k), the following simple regression equations were tested:

$Ljk/L = f(Lj/L)$ See results in Table III-4 and comments in Chapter XI.

As already pointed out, this type of equation rests on the assumption that the occupational structure of employment constitutes a valid substitute for the economic and technological indicators (Part Two), at least where fairly broad occupational categories in relation to the economy as a whole are concerned, the only ones considered in this part of the study.

Moreover these equations should allow us to examine whether changes in the weights of occupational groups in the labour force have a systematic impact on their educational profiles (levels).

ii) Levels of education of the different occupational categories and the educational structure of the total labour force

The technological indicators will be dropped here and the levels of education of the occupational categories will be linked directly with the educational structure of the labour force through the following two series of equations:

$Ljk/Lj = f\ (Lk/L)$ See results in Table III-5 and comments
$Ljk/L = f\ (Lk/L)$ in Chapter XII.

iii) Levels of education of the different occupational categories, technological indicators, occupational and/or educational structure of the labour force

A first round of *multiple* regression equations was tested using the educational structure of the labour force *and* the technological indicators as explanatory variables:

$$Ljk/Lj = f\ (Lk/L,\ n)$$

Then n was substituted for the occupational structure of employment for the same reason as before, and the following serie was run:

$$Ljk/Lj = f\ (Lk/L,\ Lj/L)$$

The results are presented in Table III-6 and III-7, and commented in Chapter XIII.

IX

EDUCATIONAL PROFILE OF THE OCCUPATIONAL CATEGORIES AND TECHNOLOGICAL INDICATORS

As already stated Ljk/Lj represents the proportion with a level of education k of the total number in occupational category j. This is certainly the first ratio which comes to mind when any attempt is made to express the "educational profile" of an occupational group in precise terms.

However, having regard to the rather unsatisfactory results obtained by Layard and Saigal when this type of measurement is adjusted for X/L, it would be unwise to expect much new light to be thrown by equations in the form: Ljk/Lj = f (n), n being any one of the technological indicators: see the full results in Table III-1.

Some of the fits are directly comparable with those in the Layard and Saigal study, which enables the following table to be compiled.

DIFFERENT VALUES OF R IN THE EQUATION

$$\log (Ljk/Lj) = \log a + b \log (X/L)$$

ISCO Major Groups / Levels of Education	0		1		2		3		TOTAL	
	LSE	OECD	LSE	OECD	LSE	OECD	LSE	OECD	LSE	OECD
a) University degree level or above ...	0.50	0.28	0.37	0.12	0.10	0.16	0.76	0.42	0.81	0.65
b) Completed secondary level or above	0.41	0.42	0.49	0.28	0.17	0.19	0.55	0.51	0.69	0.75
c) Mean years of schooling	0.57	0.40	0.67	0.58	0.50	0.34	0.70	0.63	0.75	0.74

SOURCES: OECD: see Table III-1. Number of observations: (a) 25, (b) 21 and (c) 20.
LSE : Layard and Saigal, op. cit., Table 2, page 261. Number of observations: about 19.

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Table III-1. SIMPLE REGRESSION EQUATIONS LINKING THE LEVELS OF EDUCATION OF OCCUPATIONAL CATEGORIES, (Ljk/Lj) TO SOME GENERAL ECONOMIC INDICATORS: log (Ljk/Lj) = log a + b log (n)

OCCUPATIONAL CATEGORIES		DEGREE LEVEL AND ABOVE (A)				COMPLETED SECONDARY SCHOOLING AND ABOVE (B)				MORE THAN EIGHT YEARS OF SCHOOLING (C)				EIGHT YEARS OF SCHOOLING OR LESS (D)			
		N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Major Group 0	Index	25	0.38	0.76	0.37(0.19)	21	0.53*	1.41	0.25(0.09)	17	0.41	1.71	0.13(0.07)	17	-0.38	2.00	-0.59(0.37)
	X/L	25	0.28	0.68	0.20(0.15)	21	0.42	1.32	0.15(0.07)	17	0.40	1.62	0.08(0.05)	17	-0.38	2.40	-0.40(0.25)
	ΣI/L	22	0.20	0.93	0.12(0.14)	19	0.41	1.42	0.12(0.06)	13	0.41	1.68	0.06(0.04)	13	-0.42	2.27	-0.36(0.23)
Minor Groups 00/01/02/0X	Index	19	-0.09	1.59	-0.09(0.24)	14	0.42	1.34	0.29(0.18)								
	X/L	19	-0.09	1.66	-0.06(0.17)	14	0.42	1.12	0.21(0.13)								
	ΣI/L	16	-0.01	1.45	-0.01(0.17)	12	0.40	1.19	0.18(0.13)								
Minor Group 0X	Index	12	-0.06	0.61	-0.12(0.69)	9	0.58	1.08	0.41(0.22)								
	X/L	12	-0.02	0.52	-0.03(0.50)	9	0.55	0.77	0.29(0.17)								
	ΣI/L	11	0.09	-0.01	0.10(0.39)	8	0.50	0.93	0.24(0.17)								
Major Group 1	Index	25	0.23	0.63	0.25(0.22)	21	0.34	1.19	0.25(0.16)	17	0.44	1.41	0.23(0.12)	17	-0.33	2.00	-0.30(0.22)
	X/L	25	0.12	0.69	0.10(0.17)	21	0.28	1.08	0.16(0.12)	17	0.53*	1.16	0.19(0.08)	17	-0.39	2.31	-0.24(0.15)
	ΣI/L	22	0.37	0.24	0.24(0.13)	19	0.42	0.97	0.19(0.10)	13	0.68*	1.17	0.18(0.06)	13	-0.45	2.28	-0.24(0.14)
Major Group 2	Index	25	-0.13	0.59	-0.23(0.37)	21	0.09	1.29	0.11(0.30)	17	0.26	1.62	0.12(0.11)	17	-0.40	2.01	-0.37(0.22)
	X/L	25	-0.16	0.88	-0.20(0.27)	21	0.19	0.87	0.19(0.22)	17	0.45	1.35	0.14(0.07)	17	-0.54*	2.54	-0.34(0.14)
	ΣI/L	22	-0.19	0.89	-0.21(0.25)	19	-0.01	1.52	-0.01(0.15)	13	0.31	1.55	0.08(0.07)	13	-0.40	2.08	-0.21(0.15)
Major Group 3	Index	25	0.41	-1.38	0.80(0.37)	21	0.44	-0.43	0.91(0.42)	17	0.61*	0.15	0.84(0.28)	17	-0.57*	2.40	-0.42(0.16)
	X/L	25	0.42	-2.03	0.59(0.27)	21	0.51*	-1.51	0.78(0.30)	17	0.69*	-0.62	0.64(0.17)	17	-0.63*	2.76	-0.31(0.10)
	ΣI/L	22	0.34	-1.46	0.41(0.26)	19	0.47	-0.49	0.48(0.21)	13	0.64*	0.30	0.37(0.14)	13	-0.56	2.51	-0.24(0.11)
Major Groups 7/8	Index					21	0.39	-1.07	1.02(0.56)	17	0.52	-1.82	0.91(0.39)	17	-0.28	2.11	-0.18(0.16)
	X/L					21	0.48	-2.82	0.95(0.40)	17	0.59*	-1.06	0.70(0.25)	17	-0.36	2.35	-0.16(0.10)
	ΣI/L					19	0.45	-1.15	0.54(0.26)	13	0.49	-1.28	0.44(0.24)	13	-0.31	2.19	-0.11(0.11)

Exactly concordant results could not, of course, be hoped for in the two cases; but even allowing for (i) differences of sample and (ii) differences due to certain approximations in quantifying the numbers with a particular level of education, some of the results are rather surprising. For instance, the excellent correlation obtained by Layard between graduate sales workers and productivity ($R = 0.76$) is not confirmed by our findings ($R = 0.42$); the same applies to major group 1 (administrators) with completed secondary level or above.

Bearing this in mind, too much importance should not be attached to the differences noted between two correlation coefficients, especially if the latter are low; their area of indetermination becomes increasingly larger in this case, especially if the coefficients are calculated from a relatively small number of observations. This does not alter the fact that the immense majority of the correlations shown in Table III-1 are not significant for a confidence level of 5%, and poorness of correlation is generally confirmed by the imprecision of the coefficients of elasticity, most of which are in fact less than twice their standard deviation.

Furthermore, none of the explanatory variables brings any distinct improvement in the results. Hence although the advantage of the index for productivity is as we have stated - in that it permits a better international comparison of real incomes and is less sensitive to cyclical fluctuations - it must be admitted that the effect of these two factors on our coefficients is practically nil. This observation also holds good for our "capital" variable, which is assumed to correspond roughly to the level of production techniques employed in the preceding years.

Nevertheless, in some exceptional cases the economic indicators chosen can "explain" up to a third of the variance in Ljk/Lj ($R^2 = 0.30 - 0.36$), which is still, however, very little.

We thus obtain*:

- if j represents administrators and k "more than eight years' schooling":

$$\log (Ljk/Lj) = 1.17 + \underset{(0.06)}{0.18} \log (\Sigma I/L) \qquad \begin{array}{l} R = 0.68 \\ N = 13 \end{array}$$

- if j represents sales workers and k "more than eight years' schooling":

$$\log (Ljk/Lj) = -0.62 + \underset{(0.17)}{0.64} \log (X/L) \qquad \begin{array}{l} R = 0.69 \\ N = 17 \end{array}$$

- if j represents manual workers and craftsmen and k "more than eight years' schooling":

$$\log (Ljk/Lj) = 1.06 + \underset{(0.25)}{0.70} \log (X/L) \qquad \begin{array}{l} R = 0.59 \\ N = 17 \end{array}$$

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* The list is not exhaustive; see Table III-1.

With some notable exceptions, which are too few to allow for any generalization, there thus does not appear to be any significant statistical link between Ljk/Lj and the technological indicators. The graphs which follow illustrate this point.

Graph III-1 shows labour productivity (X/L) and Ljk/Lj, where j represents the "professional and technical workers" and k, "completed secondary level or above": the correlation is R = 0.42. It is easy to see, for example, that Puerto Rico and Israel have the same productivity, whereas their respective values for Ljk/Lj are 95 and 60%. Conversely, Ljk/Lj is the same in Canada and Japan (85%), while the level of productivity is five times as high in Canada as in Japan.

Furthermore, the ratio Ljk/Lj approaches its extreme value (100%) in several countries, in some of which productivity is low (the Philippines, Japan, Hungary). Even if the t-test is applied to a country which has an average Ljk/Lj percentage, aberrant confidence limits are obtained: thus, Ljk/Lj, which equals 59% for the Netherlands, may in fact fluctuate between 38% and more than 100%. *

Graph III-2 represents one of the best correlations obtained: R = 0.69, where j corresponds to sales workers and k to "more than eight years' schooling". The real value of Ljk/Lj is 13.5% for Ecuador; but in actual fact, the extreme values calculated by the t-test are 3.2% and 61%. **

This being so, the imprecision of the statistical links between Ljk/Lj and the economic indicators clearly seems to be due to the "complex" nature of the ratio Ljk/Lj, the variations in which result from the combined variations in Ljk/Lj. In other words, the ratio increases because Ljk increases, or because Lj decreases, or because both events occur. In reality, the following may happen: the number of "managerial workers" (major group 0) with "completed secondary level or above" (Ljk) is *twice* as high in the Netherlands as in Greece, while the total numbers in major group 0 (Lj) are *three* times higher in the Netherlands; the ratio between these two magnitudes will thus be lower in the Netherlands than in Greece, although the latter has a much lower productivity level. This is a frequent phenomenon: while some industrialized countries tolerate a large fraction of certain occupational groups with less than the appropriate level of *formal* education (which may be interpreted as a sign of social mobility), some developing countries tend to limit admittance to any given occupational group to the holders of what is regarded as the adequate qualification, such as a university degree for major group 0. In their case, Ljk will thus more nearly approach Lj, which will itself be excessively small, and the ratio Ljk/Lj will be high in countries where productivity is generally low.

The choice of Ljk/Lj as a dependent variable thus entails two serious drawbacks: imprecision of the statistical relationships owing to the very nature of the ratio, and an upper limit which is too close not to interfere with the correlations in cases where Ljk is close to Lj, which will be all the more frequent as the levels of education chosen are cumulative.

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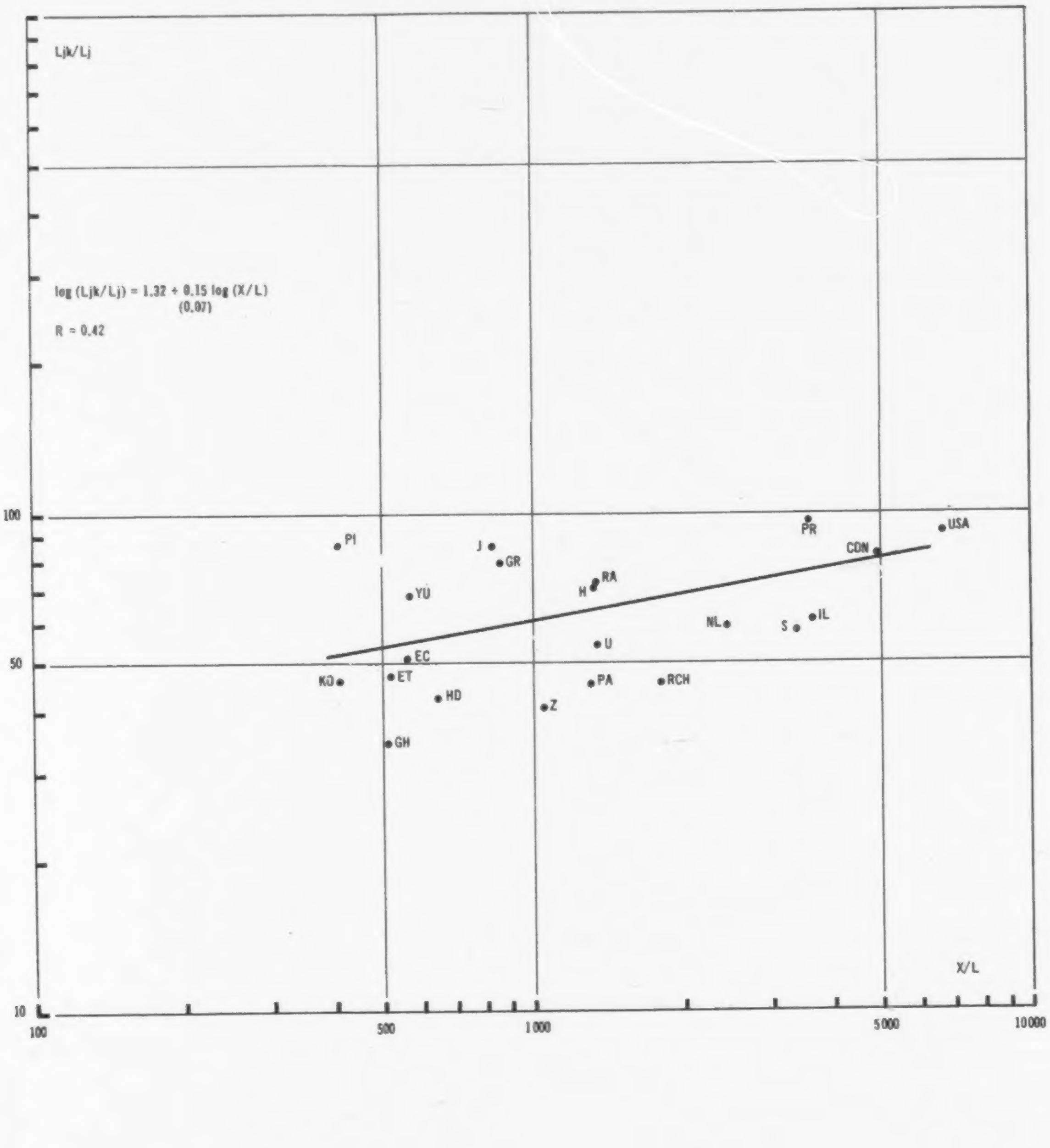
* At the confidence level of 95%.

** Admittedly, Zambia and Egypt largely account for the inaccuracy of the estimates, but other countries (Japan, Greece, Hungary), which are responsible for poor correlations at the "completed secondary level or above", are not included here for lack of data.

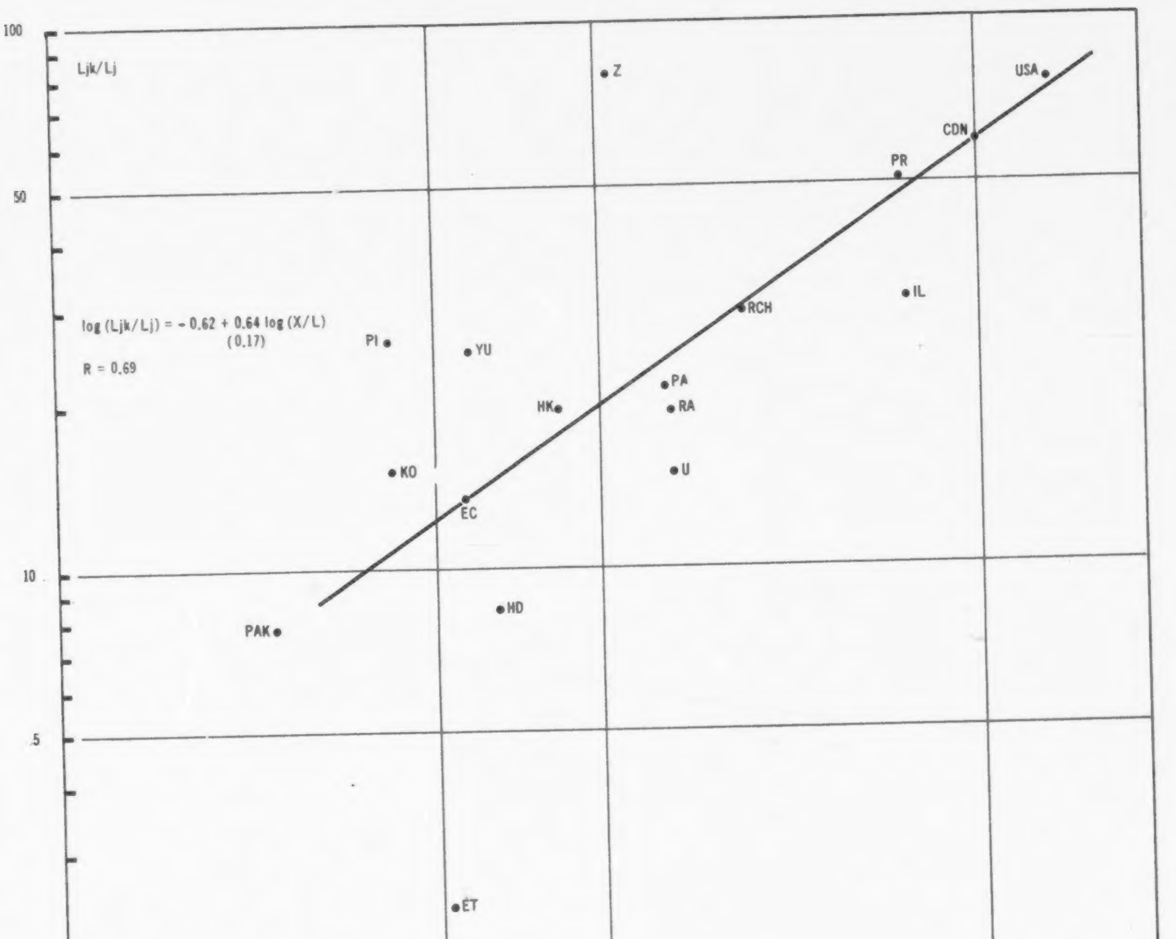
Graph III-1

NUMBER OF «PROFESSIONAL AND TECHNICAL WORKERS» WITH «COMPLETED SECONDARY SCHOOLING AND ABOVE», AS A PROPORTION OF TOTAL NUMBER IN THIS CATEGORY (Ljk/Lj), AND OUTPUT PER WORKER (X/L)



Graph III-2

NUMBER OF «SALES WORKERS» WITH «MORE THAN EIGHT YEARS OF SCHOOLING», AS A PROPORTION OF TOTAL NUMBER IN THIS CATEGORY (Ljk/Lj), AND OUTPUT PER WORKER (X/L)



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The lack of a significant statistical relationship observed in this Chapter could also be interpreted by some in more positive terms: it shows a remarkable flexibility of occupation-education patterns at analogous levels of development.

We shall now consider whether the use of Ljk/L as a dependent variable is likely to yield more precise econometric relationships, while supplying the same information.

X

LEVELS OF EDUCATION OF THE OCCUPATIONAL CATEGORIES AND TECHNOLOGICAL INDICATORS

This chapter will be divided in four main sections; in the first two, the results of the equations Ljk/L = f (n) will be compared with those of Lj/L = f (n) and with those of Lk/L = f (n). Then a third section will be devoted to a summary of the main econometric relationships. Finally the mean years of education of occupational categories will be related to the technological indicators.

1. Ljk/L, Lj/L AND THE TECHNOLOGICAL INDICATORS

As noted above, the use of Ljk/L as a dependent variable should allow, among other things, direct comparisons with Lj/L = f (n), thus revealing the effect of weighting the groups j by the levels of education k.

The introduction of k may, indeed, be expected, in certain cases at least, to improve the results obtained with the occupational structure alone; this proposition is, at bottom, only a variant of our general basic hypothesis, which assumed a significant statistical link between levels of education and levels of development.

The full results of these regression analyses will be found in Table III-2; the equations Ljk/L = f (n) are shown in the first 16 columns*, and equations Lj/L = f (n) in columns 17 to 20.** This section will therefore be devoted to "horizontal" comparisons of the various correlation figures within each occupational category.

Our expectations were not confirmed in the case of major group 0***; the figures obtained for the occupational structure alone (Lj/L) are generally better than those obtained after introducing any specific educational

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* In actual fact, we shall here refer only to the first three levels of education: university degree, completed secondary, and more than eight years' schooling, for which the results are shown in the first twelve columns. There can, indeed, be no significant correlation at the "eight years' schooling or less" level (columns 13 to 16) when the occupational categories are taken individually.

** Calculated from the maximum available number of observations, i.e., with the same samples as those used for the "university degree (A)" level; always with the exception of major group 7/8, for which Lj/L = f (n) was calculated with the samples used at "completed secondary level or above (B)". The Ljk/L percentages at university level were not, in fact, used for this group, as they were too small to be significant.

*** Professional and technical workers.

Table III.2. SIMPLE REGRESSION EQUATIONS LINKING
the Levels of Education of Occupational Categories, (Ljk/L)
the Occupational Structure, (Lj/L)
the Educational Structure, (Lk/L)

TO SOME GENERAL ECONOMIC INDICATORS
Index log (Lj/L)
X/L log (Ljk/L)
ΣI/L log (Lk/L)
= log a + b log (n)

OCCUPATIONAL CATEGORIES		DEGREE LEVEL AND ABOVE (A)				COMPLETED SECONDARY SCHOOLING AND ABOVE (B)				MORE THAN EIGHT YEARS OF SCHOOLING (C)				EIGHT YEARS OF SCHOOLING OR LESS (D)				OCCUPATIONAL STRUCTURE Lj/L			
		N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Major Group 0	Index	25	0.79*	-1.82	1.23(0.20)	21	0.87*	-1.02	1.02(0.13)	17	0.85*	-0.80	0.95(0.15)	17	0.16	-0.50	0.24(0.39)	25	0.90*	-0.58	0.85(0.09)
	X/L	25	0.73*	-2.59	0.84(0.17)	21	0.81*	-1.72	0.71(0.12)	17	0.85*	-1.43	0.64(0.10)	17	0.16	-0.66	0.16(0.26)	25	0.90*	-1.28	0.63(0.06)
	ΣI/L	22	0.64*	-1.87	0.61(0.16)	19	0.81*	-1.28	0.57(0.10)	13	0.87*	-0.98	0.51(0.08)	13	0.11	-0.40	0.09(0.24)	22	0.87*	-0.80	0.48(0.06)
Minor Groups 00/01/02/0X	Index	19	0.77*	-2.63	1.35(0.27)	14	0.88*	-2.11	1.27(0.20)									19	0.82*	-2.22	1.43(0.25)
	X/L	19	0.76*	-3.46	0.92(0.19)	14	0.85*	-2.94	0.88(0.16)									19	0.82*	-3.11	0.99(0.17)
	ΣI/L	16	0.75*	-2.85	0.72(0.17)	12	0.81*	-2.64	0.78(0.18)									16	0.75*	-2.30	0.72(0.17)
Minor Group 0X	Index	12	0.31	-2.83	0.71(0.68)	9	0.73*	-2.19	1.12(0.40)									12	0.62*	-1.44	0.83(0.33)
	X/L	12	0.31	-3.32	0.50(0.49)	9	0.60	-2.68	0.70(0.35)									12	0.55	-1.83	0.53(0.26)
	ΣI/L	11	0.43	-3.62	0.56(0.39)	8	0.56	-2.37	0.60(0.36)									11	0.53	-1.61	0.45(0.24)
Major Group 1	Index	25	0.68*	-2.54	1.17(0.27)	21	0.74*	-1.87	1.14(0.24)	17	0.71*	-1.76	1.24(0.32)	17	0.41	-1.18	0.71(0.41)	25	0.71*	-1.16	0.92(0.19)
	X/L	25	0.63*	-3.28	0.80(0.21)	21	0.79*	-3.03	0.91(0.16)	17	0.80*	-2.93	0.95(0.19)	17	0.44	-1.78	0.52(0.27)	25	0.73*	-1.97	0.70(0.14)
	ΣI/L	22	0.68*	-3.10	0.74(0.18)	19	0.78*	-2.52	0.75(0.14)	13	0.75*	-2.24	0.73(0.20)	13	0.30	-1.13	0.31(0.30)	22	0.63*	-1.34	0.50(0.14)
Major Group 2	Index	25	0.32	-2.04	0.69(0.42)	21	0.58*	-1.34	1.05(0.34)	17	0.87*	-1.04	1.09(0.16)	17	0.43	-0.64	0.60(0.33)	25	0.84*	-0.63	0.92(0.12)
	X/L	25	0.28	-2.37	0.44(0.32)	21	0.62*	-2.40	0.84(0.24)	17	0.91*	-1.86	0.77(0.09)	17	0.30	-0.68	0.29(0.24)	25	0.79*	-1.25	0.64(0.10)
	ΣI/L	22	0.21	-1.91	0.29(0.30)	19	0.55*	-1.35	0.52(0.19)	13	0.82*	-1.26	0.58(0.12)	13	0.38	-0.74	0.29(0.22)	22	0.75*	-0.80	0.50(0.10)
Major Group 3	Index	25	0.53*	-3.05	1.11(0.37)	21	0.58*	-2.11	1.23(0.39)	17	0.74*	-1.59	1.21(0.28)	17	-0.04	0.65	-0.06(0.42)	25	0.29	0.33	0.31(0.21)
	X/L	25	0.50*	-3.81	0.78(0.28)	21	0.61*	-3.30	0.96(0.29)	17	0.78*	-2.51	0.85(0.18)	17	-0.09	0.87	-0.10(0.29)	25	0.23	0.22	0.18(0.16)
	ΣI/L	22	0.44	-3.20	0.58(0.26)	19	0.60*	-2.27	0.65(0.21)	13	0.68*	-1.53	0.55(0.18)	13	-0.07	0.67	-0.06(0.28)	22	0.25	0.26	0.17(0.15)
Major Groups 7/8	Index					21	0.61*	-2.79	1.71(0.51)	17	0.73*	-1.81	1.53(0.37)	17	0.26	0.49	0.45(0.43)	21	0.58*	0.28	0.69(0.22)
	X/L					21	0.65*	-4.48	1.35(0.37)	17	0.75*	-2.89	1.06(0.24)	17	0.17	0.52	0.20(0.30)	21	0.45	0.03	0.40(0.18)
	ΣI/L					19	0.66*	-2.87	0.87(0.24)	13	0.70*	-1.90	0.76(0.24)	13	0.20	0.42	0.21(0.30)	19	0.44	0.28	0.33(0.16)
Educational Structure (Lk/L)	Index	25	0.71*	-1.43	1.09(0.22)	21	0.76*	-0.69	1.09(0.22)	17	0.81*	-0.40	1.12(0.21)	17	-0.86*	2.44	-0.27(0.04)				
	X/L	25	0.65*	-2.10	0.74(0.18)	21	0.75*	-1.60	0.81(0.16)	17	0.84*	-1.24	0.79(0.13)	17	-0.85*	2.72	-0.40(0.06)				
	ΣI/L	22	0.57*	-1.47	0.54(0.17)	19	0.73*	-0.97	0.61(0.14)	13	0.76*	-0.49	0.56(0.14)	13	-0.83*	2.58	-0.23(0.05)				

level, whichever of the three economic variables is considered. Apparently, therefore, the education factor introduces a rigid element into the equation, which may be explained in different ways.

- First, it may be considered somewhat naive to expect a perfect fit between productivity and the level of education of professional workers; every year brings forth a batch of young graduates who try to break into the labour market, while the level of X/L partly depends on certain cyclical factors whose influence is by no means negligible. The same situation is found, however, if the fits obtained for the non-monetary index, rendered much less sensitive to economic conditions by its composition, are considered.

- A more convincing explanation lies in the fact that major group 0 includes certain professions for which a university degree is required (medicine, the bar, a proportion of teaching posts and, generally speaking, all the "traditional" professions) to a varying extent, according to the country and for reasons having little to do with the economic variables.

Graphs III-3 and III-4 with X/L as the X-axis and Lj/L and Ljk/L as the Y-axis (j major group 0, k university degree) bring out more clearly the role of k in the correlations. Graph III-3 reveals that three countries are much above the line of estimation - Yugoslavia, Hungary and Israel; in Graph III-4 Israel comes into line while four other countries* join Yugoslavia and Hungary above it. It would thus appear that weighting by k has different effects on different countries:

- it corrects a problem of occupational classification in the case of Israel;

- it reveals that the numerical importance of Lj in Hungary and Yugoslavia is "supported" by an equally high value for Ljk;

- lastly, it suggests that certain low-productivity countries* can nevertheless boast a higher-than-average number of professional workers with university degrees. It is not immaterial that these countries should be specifically identified.

Lastly, such countries as Honduras and Ghana, which were in perfect alignment in Graph III-3, clearly fall below the line in Graph III-4, indicating a deficiency of university education in major group 0 in these countries.

The figures for scientific and technical workers** reveal that there is no significant difference between the correlations obtained with

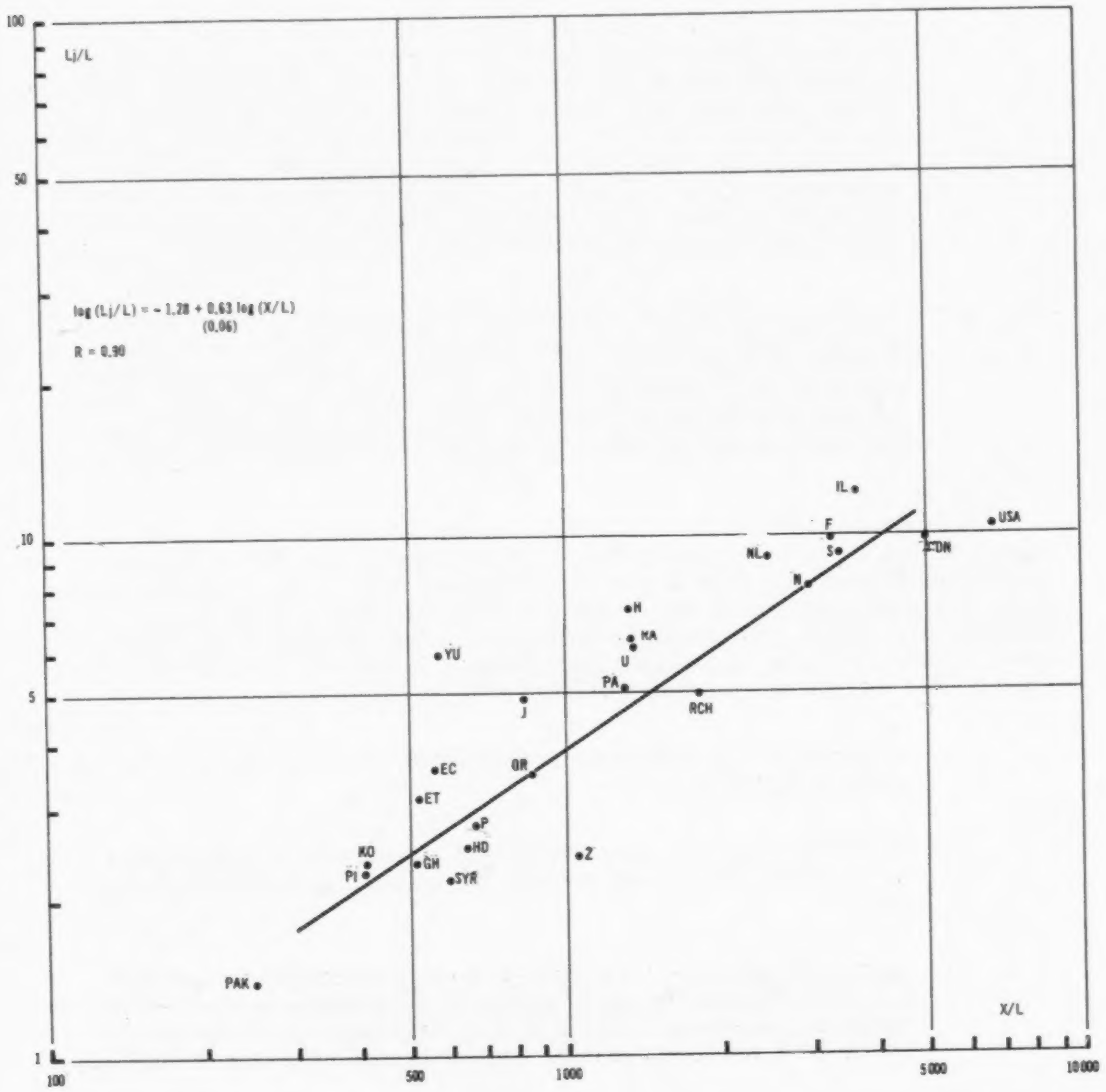
---

* The Philippines, Egypt, Japan, Greece.

** Sub-groups 00/01/02/0X.

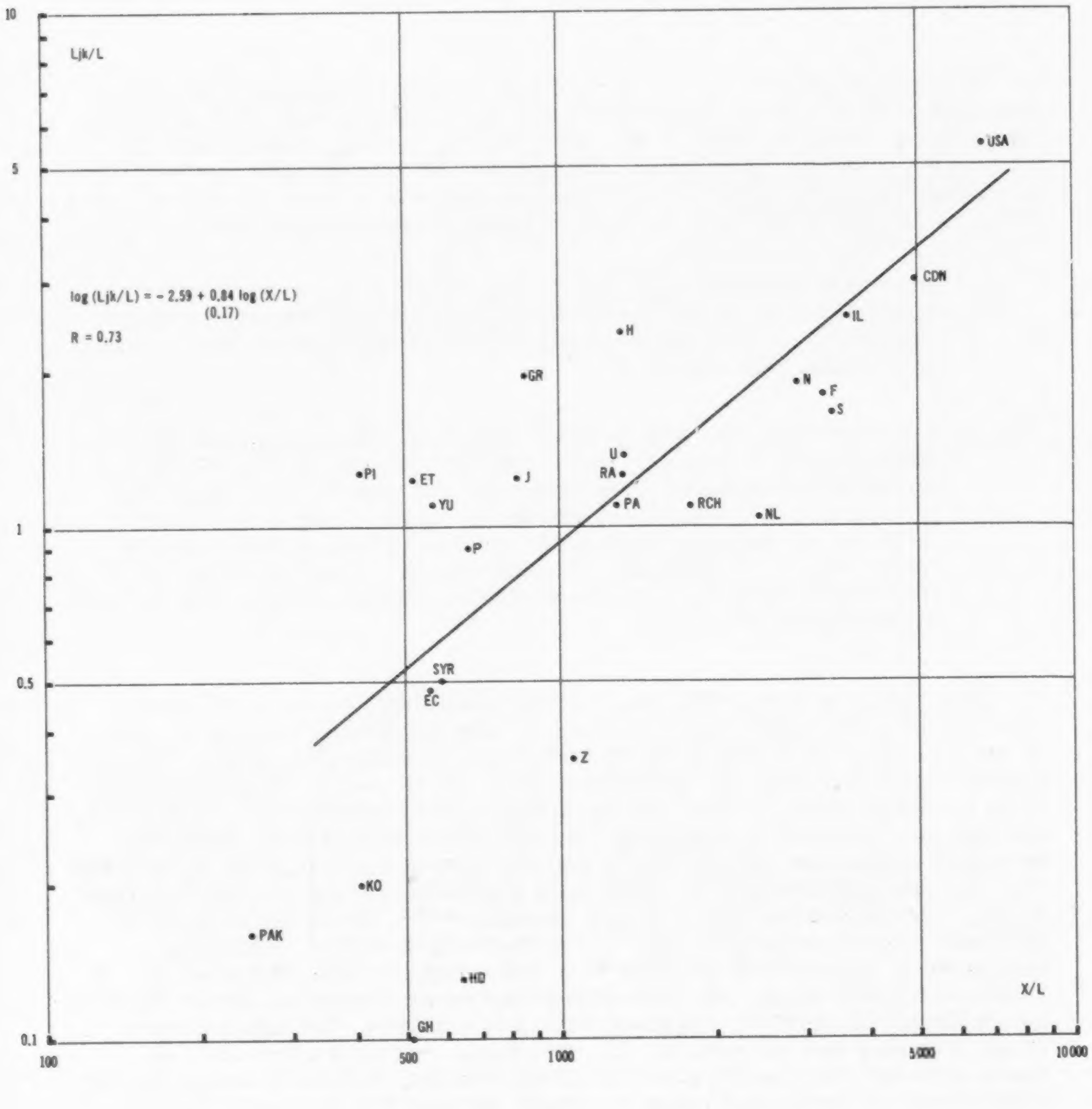
Graph III-3

NUMBER OF «PROFESSIONAL AND TECHNICAL WORKERS», AS A PROPORTION OF TOTAL EMPLOYMENT (Lj/L), AND OUTPUT PER WORKER (X/L)



Graph III-4

NUMBER OF «PROFESSIONAL AND TECHNICAL WORKERS, WITH «UNIVERSITY DEGREE», AS A PROPORTION OF TOTAL EMPLOYMENT (Ljk/L), AND OUTPUT PER WORKER (X/L)



Lj/L and Ljk/L. This seems to bear out what has already been said about the disturbance caused by the proportion of graduates in non-scientific occupations; when those are deducted from major group 0, as is the case here, correlations with or without k are of comparable quality, fluctuating around $R = 0.80$.

If technicians (0X) are now taken as a separate group of scientific and technical workers, the figures will be disappointing, both for Lj/L and Ljk/L. At university level, this will hardly cause surprise, as very few countries have higher educational establishments specifically designed for technicians* at "completed secondary level or above", on the other hand, there seem to be two possible interpretations:

- errors of observation, which are known to be particularly frequent for the technician category, artificially reduce to real correlation coefficient through the bias of a systematic increase in the true variance σX^2;

- alternatively, the link between Ljk/L and the economic variables is really weak or non-existent: the manpower studies in developing countries thus bring out the under-representation of middle-level scientific workers, while at the same time drawing attention to such quite special circumstances as the inclusion of commercial, sanitary or other technicians. It is thus not surprising that the statistical links should seem to lack significance. **

For major group 1***, the correlations obtained for Lj/L and Ljk/L are fairly comparable; at most, some differences may be noted at university level for X/L (0.73 and 0.63 respectively), and at "completed secondary level or above" for $\Sigma I/L$ (0.63 and 0.78 respectively). This category does, indeed, raise some serious problems of definition, and the new entrants undoubtedly are admitted with largely different levels of education. However, a comparison of correlations as between the various Ljk/L's and the economic variables reveals some "preferential" levels of education for this category****, such as "completed secondary level or above" and "more than eight years' schooling". Graph III-5, moreover, reveals two sub-samples which behave in rather different ways; we find almost the same countries above the line as on Graph III-4*****, together with a few others, including Puerto Rico, Panama and Argentina. Correlations calculated for each of these sub-samples would give excellent results, but the reasons for the differences in behaviour must be sought outside the economic variables.

* In many countries, "technicians" with university degrees will be young people at the start of their careers, marked out for fairly rapid promotion.

** See, however, the results obtained in Part Two, for Lj/L and certain economic variables, even though some are admittedly different from ours.

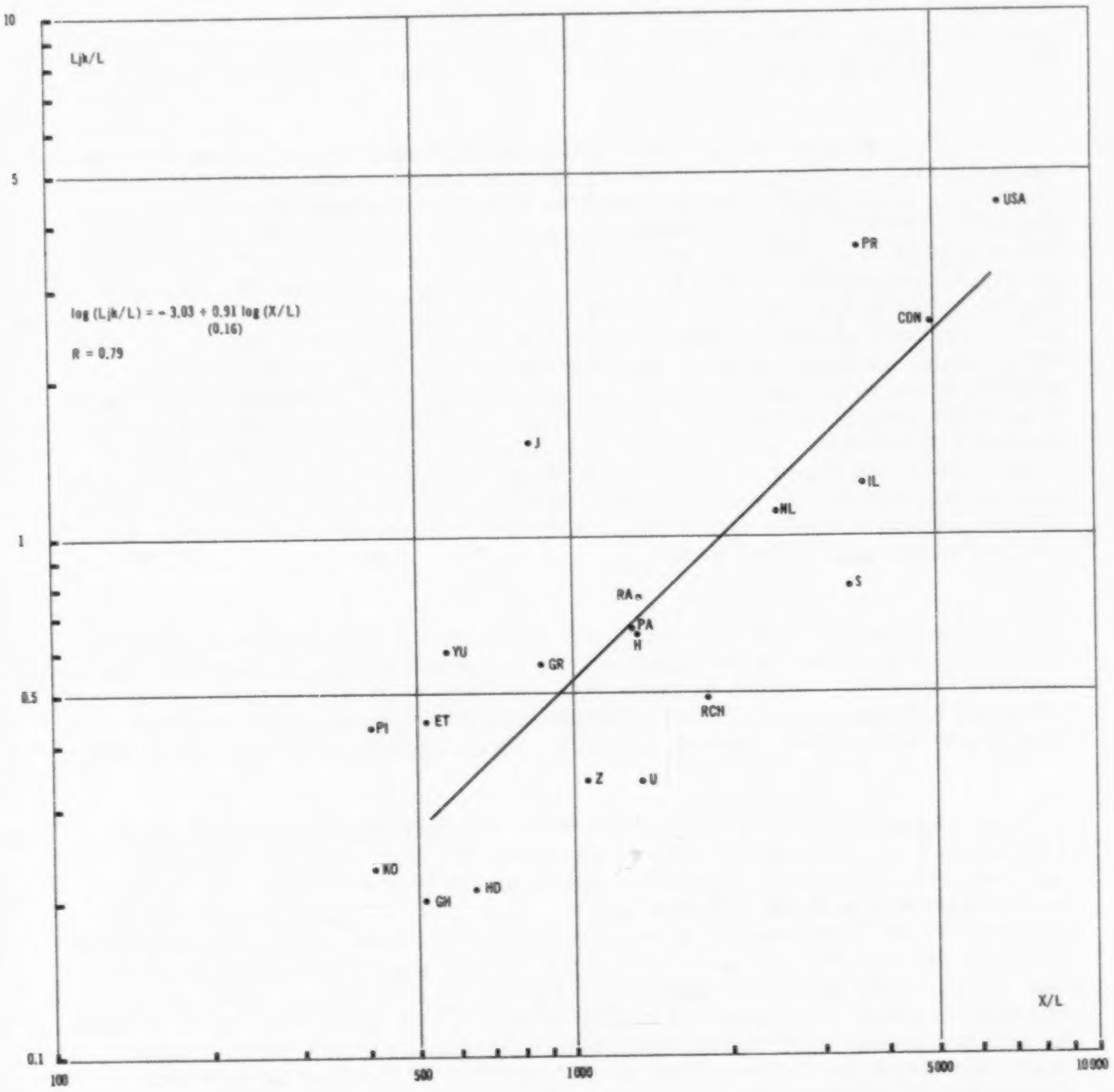
*** Administrative, executive and managerial workers.

**** i.e., those which give the best fit.

***** The Philippines, Egypt, Japan, Greece, Yugoslavia, Hungary.

Graph III-5

NUMBER OF «ADMINISTRATIVE, EXECUTIVE AND MANAGERIAL WORKERS» WITH «COMPLETED SECONDARY SCHOOLING AND ABOVE», AS A PROPORTION OF TOTAL EMPLOYMENT (Ljk/L), AND OUTPUT PER WORKER (X/L)



For major group 2 - "more than eight years' schooling" - the preferential level of education is particularly clear: $R > 0.80$ for all three variables. The correlation between Ljk/L and X/L at this level is shown in Graph III-6; one group of countries, this time "under-educated" countries, deviates somewhat from the line.* Lastly, some countries found to be "over-educated" at university level (Graph III-4) or at secondary level (Graph III-5) are here fairly well aligned.**

Major group 3*** has the peculiarity of being the only non-manual occupational category which shows no significant correlation with productivity, thus confirming the results already obtained with larger samples.**** It is not certain, however, that this statistical independence would be confirmed with every sample; it can, thus, be at least partly accounted for by the fact that developing countries are strongly represented in our sample, where an appreciable proportion of the sales workers group is under-employed (street vendors, etc.). On the other hand, as soon as Lj/L is weighted by any educational level k, significant correlations appear, especially when k represents the "more than eight years' schooling" level (from 0.68 to 0.78, according to the variable selected). This seems to indicate that in any sample of countries where the mass of sales workers possesses a good level of formal education, and is therefore fully integrated in the more modern sectors of the economy, there would be significant statistical correlations with certain economic indicators.

Thus, the fact that this category needs to be weighted by a level of education k in order to be significantly correlated with productivity or another variable, seems to show that, in many countries, this group includes a large stock of semi-illiterates, which make its definition highly problematical: street vendors, small independent business, etc.

As regards major groups 7/8*****, the introduction of a level of education k will distinctly help to improve the correlations between Lj/L and the economic variables which are only mediocre: the least unsatisfactory is 0.58 with the Index. The improvement is especially noteworthy at "completed secondary level and above", with the variables $\Sigma I/L$ (0.66) and X/L (0.65), and at the "more than eight years' schooling" level, with the three indicators ($0.70 < R < 0.75$). It may seem strange that the proportion of major group 7/8 at secondary level should be fairly closely correlated with labour productivity, in view of what was said about the composition of our sample in the last paragraph. Graph III-7 indicates the fictitious nature of the fit: it is, in fact, largely due to the extreme points******, while the central part shows almost a perfect scatter.

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* Zambia, Honduras, Ecuador.

** Egypt, the Philippines and Yugoslavia although for a different occupational category.

*** Sales workers.

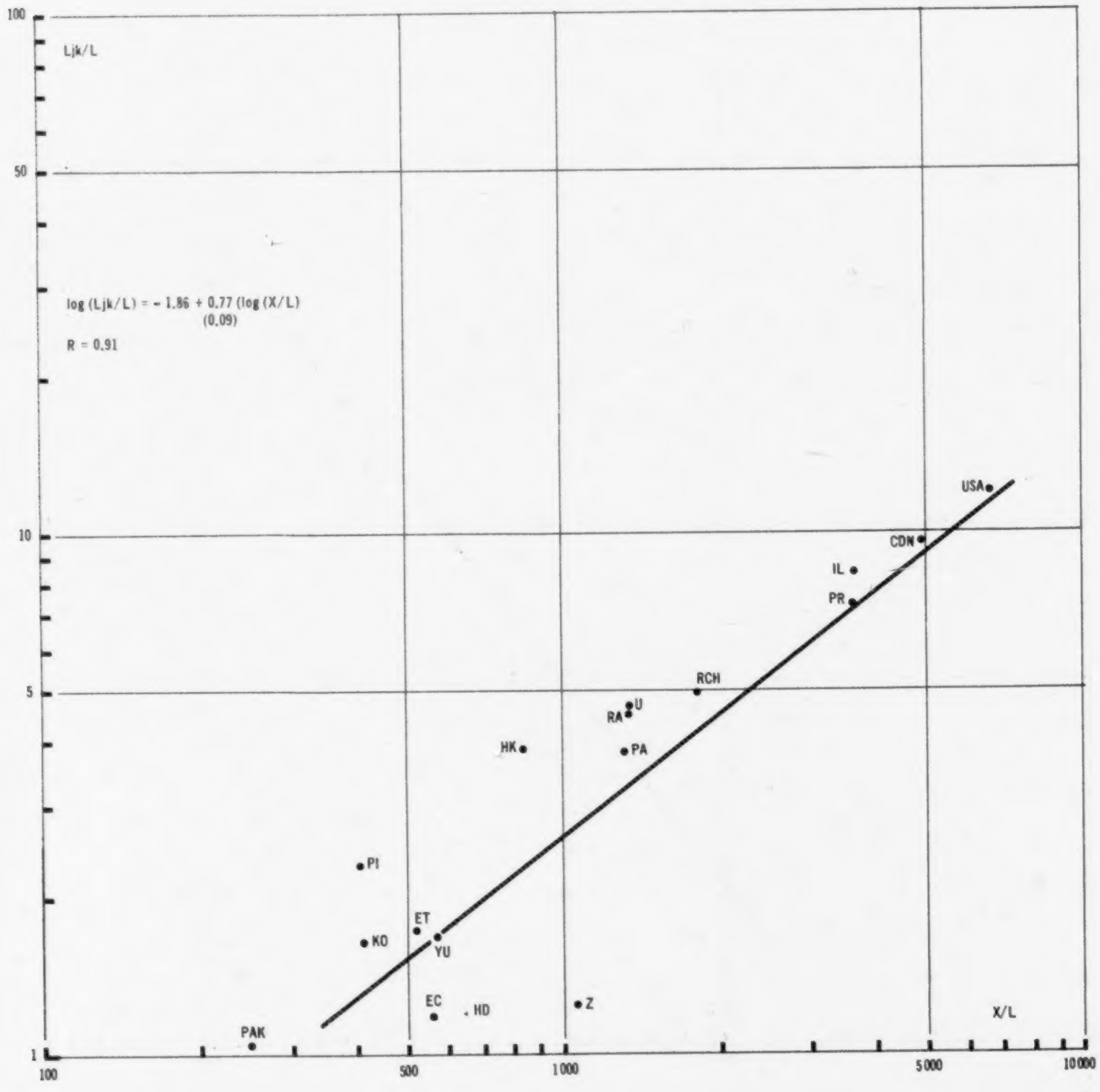
**** See Part Two.

***** Craftsmen and production process workers.

****** United States, Puerto Rico and Canada for high values of Ljk/L; Ecuador, Ghana, Honduras and Egypt for very low values.

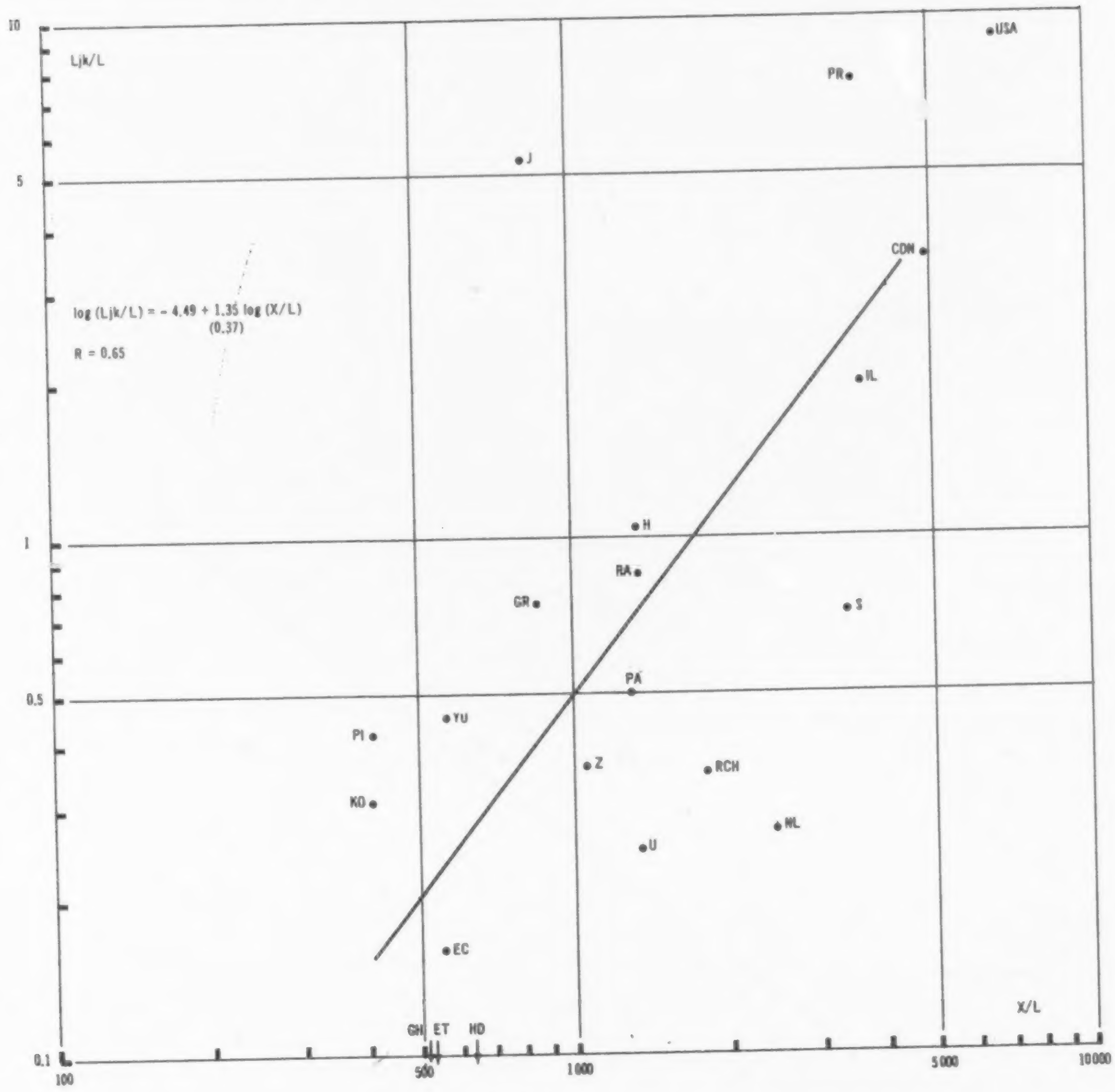
Graph III-6

NUMBER OF «CLERICAL WORKERS» WITH «MORE THAN EIGHT YEARS OF SCHOOLING», AS A PROPORTION OF TOTAL EMPLOYMENT (Ljk/L), AND OUTPUT PER WORKER (X/L)



Graph III-7

NUMBER OF «CRAFTSMEN AND PRODUCTION WORKERS» WITH «COMPLETED SECONDARY SCHOOLING AND ABOVE», AS A PROPORTION OF TOTAL EMPLOYMENT (Ljk/L), AND OUTPUT PER WORKER (X/L)



It is more interesting to compare Graphs III-8 and III-9, incorporating in turn Lj/L and Ljk/L (k more than eight years' schooling) with productivity: Graph III-8 shows that, starting at a certain level of development symbolized by $X/L > 1000$, the mass of manual workers and craftsmen tends to account for a maximum of about 30% of total employment; Graph III-9, on the other hand, shows a vigorous expansion of Ljk/L in relation to productivity, especially above the level $X/L = 1000$. It thus seems that, while the proportion of manual workers and craftsmen in the labour force may grow together with X/L in the first stages of development, a minimum of education for a growing proportion of this group subsequently becomes a necessity.

*

* *

The comparison of the correlations obtained between different economic variables and Lj/L and Ljk/L in turn, allowed us to indicate preferential levels of education in each occupational category. It would be easy to confirm that the percentages shown represent very high numbers in absolute figures. They thus undoubtedly count for a great deal. It was not our aim to seek the best possible correlations for all occupational categories with all levels of education. The fact that the proportion of clerical workers with university degrees in the total labour force is poorly correlated with productivity, probably means that such a level of education for this occupational group is not an absolute economic requirement, although it is conceivable in countries which can afford it. In these cases, it may be a symbol of social demand overshooting the minimum economic requirements, thus resulting in what we have called, educational supply effects.

2. Ljk/L, Lk/L AND THE TECHNOLOGICAL INDICATORS

It may be of interest to compare the correlations obtained for the different economic variables with Lk/L and Ljk/L in turn. Some authors uphold the argument of a direct relationship between the educational structure of the labour force and certain economic indicators[*] because of the inherent difficulties of translating occupational categories into levels of education. Still referring to Table III-2, a "vertical" comparison must this time be made of the correlations obtained with Ljk/L and with Lk/L for each level of education.[**] The comparison will be facilitated by the fact that the number of observations is strictly the same for all the major occupational groups, and for the labour force as a whole.[***]

1. There is at least one level of education for which the direct connection between Lk/L and the economic variables is unquestionably of more interest than the detour through the occupational categories (Ljk/L); this is the "eight years' schooling or less" level, to which we have so far paid little attention. At this level, we obtain a high negative correlation with the educational structure, and non-significant results when the occupational categories are taken one by one. This clearly shows

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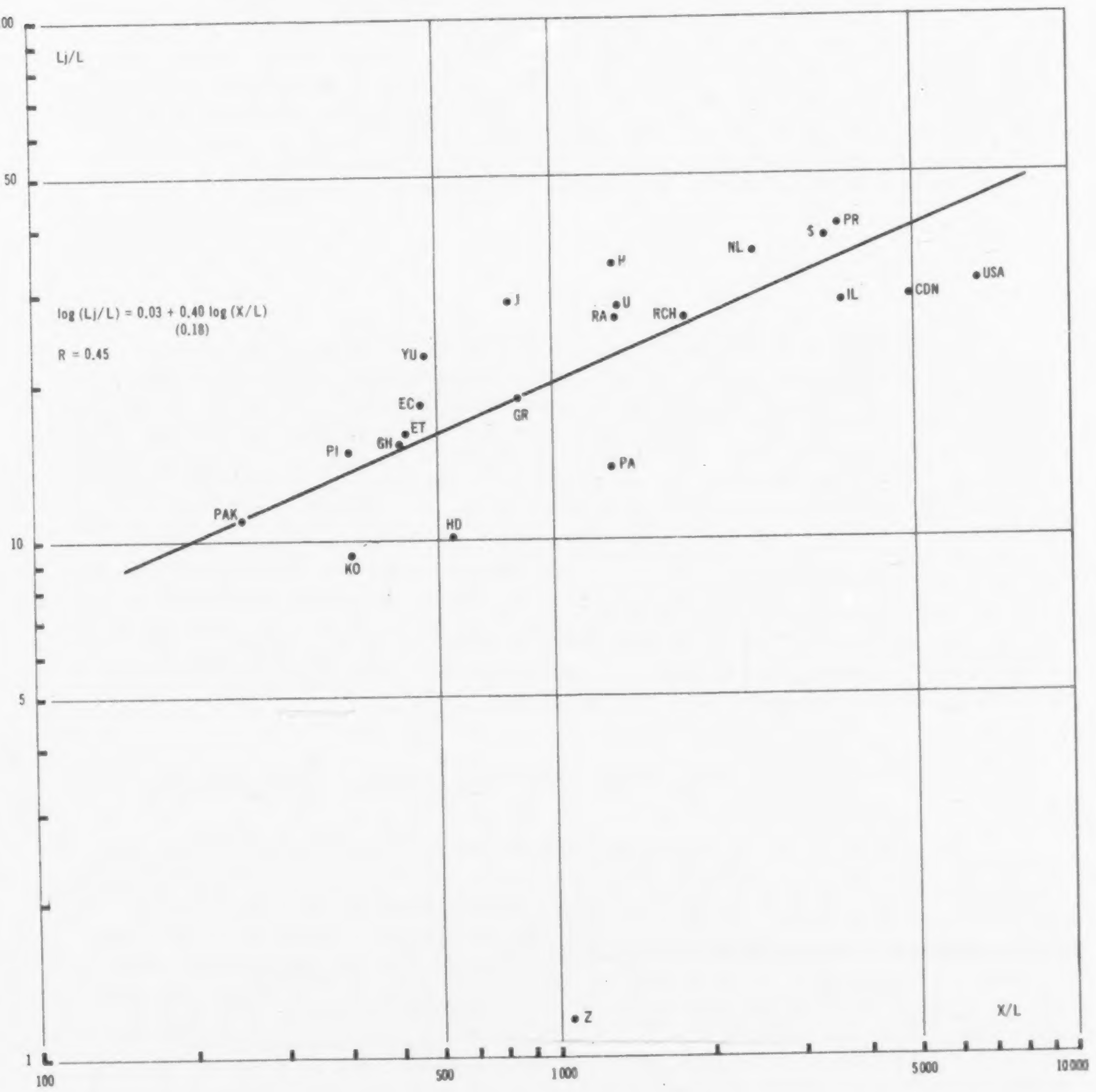
[*] See note[**], p. 104.

[**] Equations $Lk/L = f(n)$ are shown in the last three lines of Table III-2.

[***] But distinctly smaller for sub-groups 00/01/02/0X and 0X.

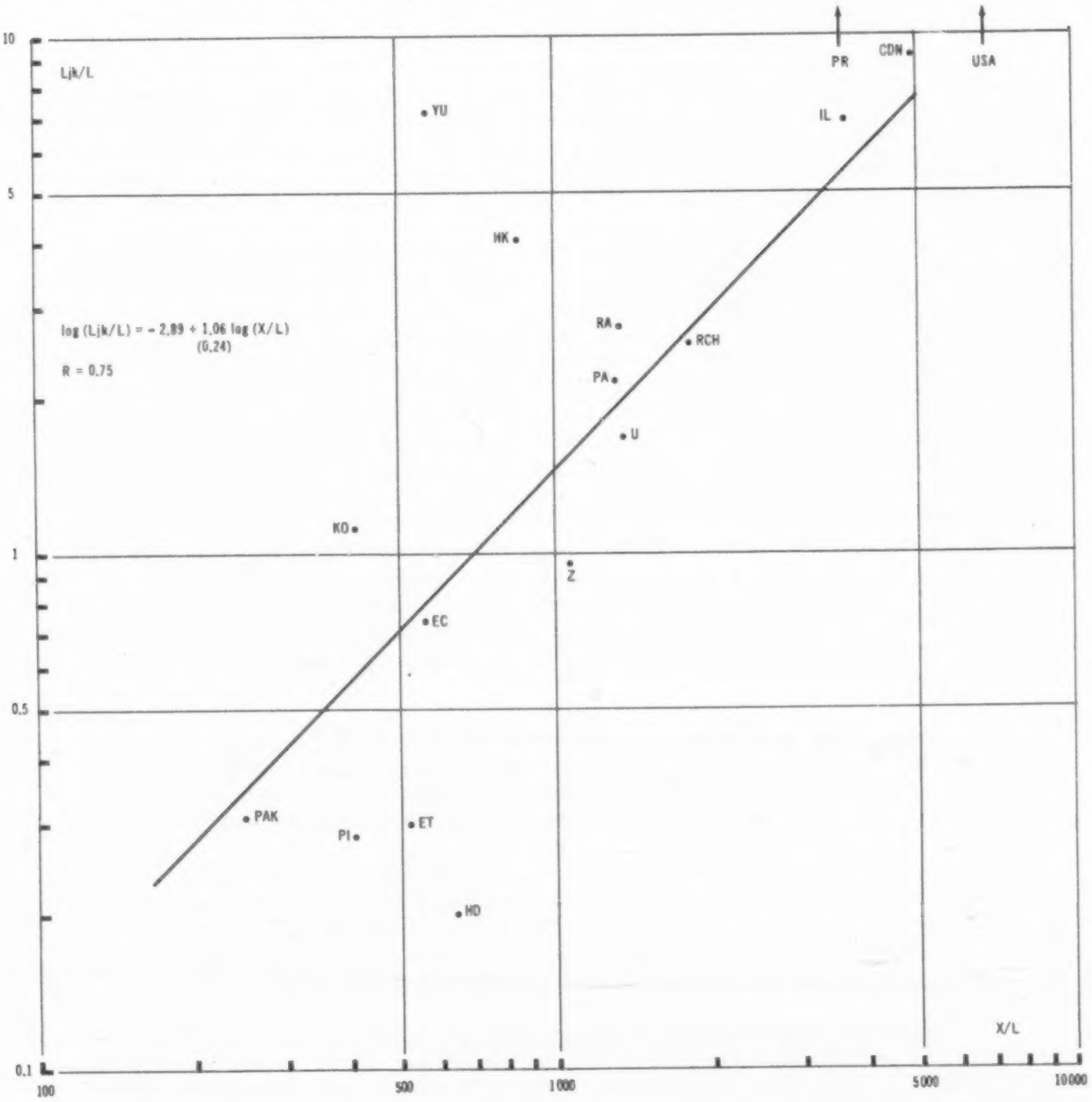
Graph III-8

NUMBER OF «CRAFTSMEN AND PRODUCTION WORKERS», AS A PROPORTION OF TOTAL EMPLOYMENT (Lj/L), AND OUTPUT PER WORKER (X/L)



Graph III-9

NUMBER OF «CRAFTSMEN AND PRODUCTION WORKERS» WITH «MORE THAN EIGHT YEARS OF SCHOOLING», AS A PROPORTION OF TOTAL EMPLOYMENT (Ljk/L), AND OUTPUT PER WORKER (X/L)



that the technological indicators cannot explain the occupational distribution of the numbers with eight years' schooling or less, which is no doubt determined by the traditional market criteria prevailing in each country. For employment as a whole, on the other hand, the very close connection between these numbers and productivity, for example, is a good sign that a long period of general education for the majority has some influence on economic development. Graph III-10 showing Lk/L = f (X/L), with k representing the "eight years' schooling or less" level, also indicates that correlation would be better still if instead of a log linear function, a function with a varying elasticity were chosen, adopting an asymptote equal to 100% for Lk/L, as X/L diminishes.

2. The situation is less clear with the levels of education A, B, C, which give in turn a better, equal or inferior correlation with Lk/L as compared with that obtained with Ljk/L. These comparisons may, admittedly, seem aimless at first sight, if the final object is to obtain a satisfactory estimate of Lk. Furthermore, a more precise estimate for one Ljk/L would probably be offset by unsatisfactory estimates for other Ljk/L's, if the estimate for Lk/L itself is average. It may, however, be of some interest to note the occupational categories for which a good fit can be obtained, even if other explanatory variables have to be considered for the other categories. It would then be possible to add up the various estimates of Ljk/L to obtain Lk/L. This being granted, the correlations between Ljk/L and the economic indicators at university degree level are slightly better than those with Lk/L in two cases only: major group 0 and scientific and technical workers (00/01/02/0X). The weighting of the number of university graduates by one or other of these categories thus provides an additional appreciable source of accuracy.

By comparing Graph III-11, showing Lk/L = f (X/L), with Graph III-4, it can be seen, first, that in each case the same countries are found clearly above the line*, and secondly, that the introduction of j, major group 0, does not suffice to bring them into alignment. **

Graph III-12 was plotted for Ljk/L, j this time representing scientific and technical manpower, in the hope that this type of personnel might improve the fit of Graph III-4. *** This was not so; Graph III-12 shows no appreciable improvement on the scatter noted in Graph III-4. At most, certain countries are found to have changed their position.

At "completed secondary level or above", correlations for Ljk/L are slightly better than those for Lk/L for major group 0 and sub-groups 00/01/02/0X, roughly the same for major group 1, and worse for the other occupational categories.

Lastly, at the "more than eight years' schooling" level, the "sales workers" group is the only one to show a slightly better fit than can be obtained for Lk/L.

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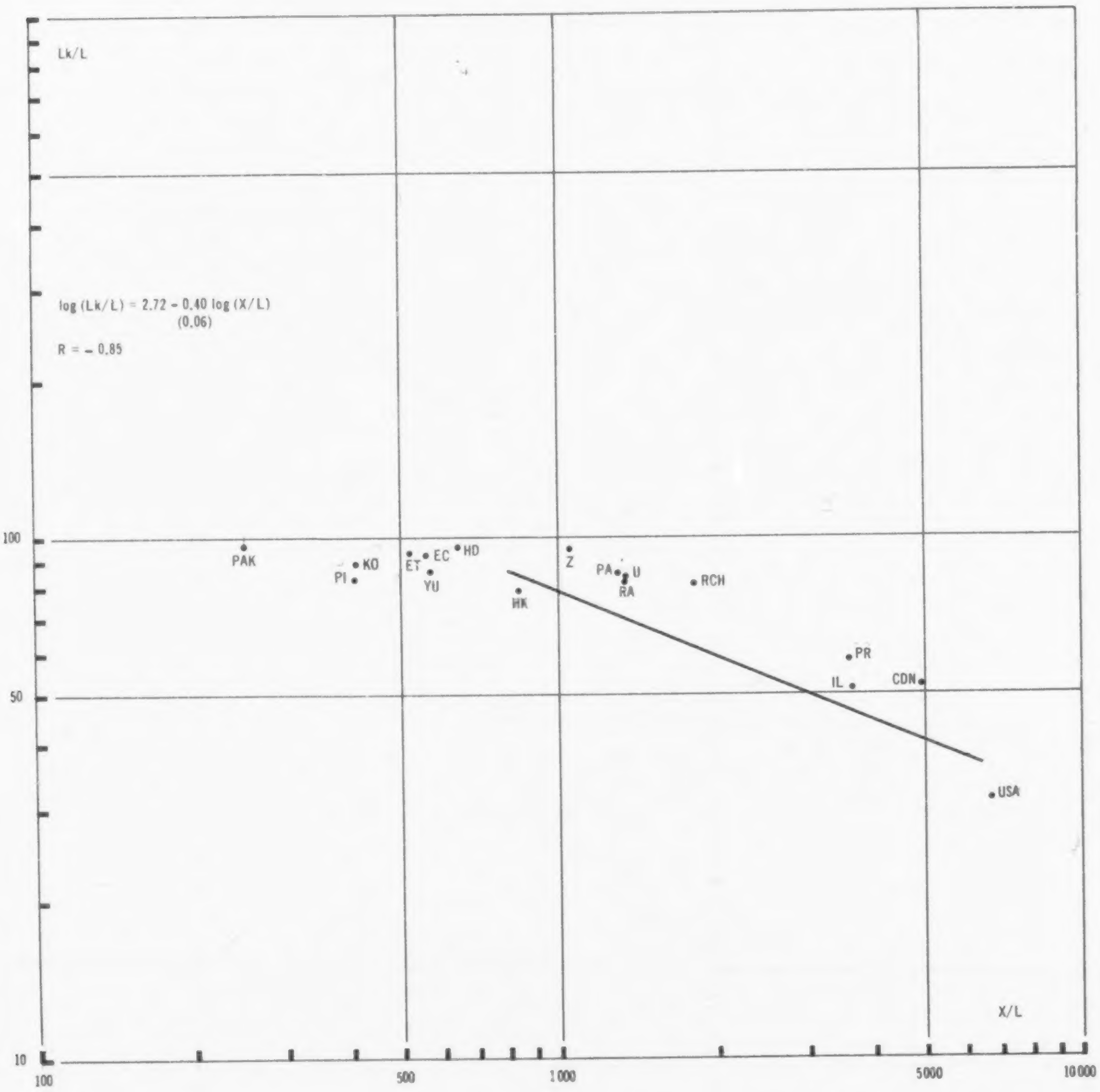
* The Philippines, Japan, Greece, Hungary, Egypt and Yugoslavia, to mention only the chief countries.

** There are, in fact, nine countries on Graph III-4 for which Ljk/L fluctuates around 1,2%, while their productivity ranges from 400 to 2,500 dollars per head.

*** The "over-production" of university graduates is, indeed, more likely to represent an "over-production" of non-scientific graduates.

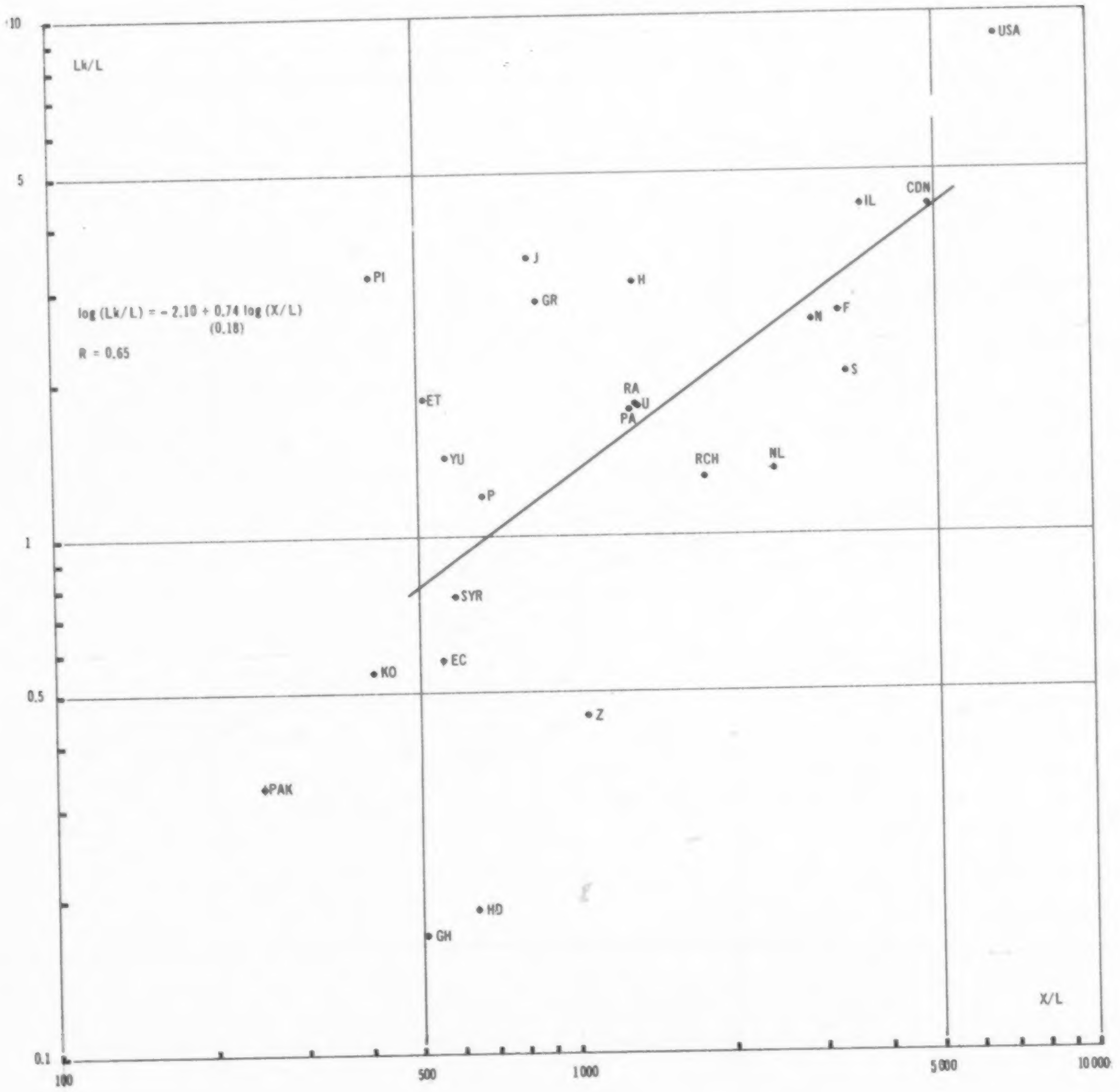
Graph III-10

NUMBER OF PERSONS WITH «EIGHT YEARS OF SCHOOLING AND LESS», AS A PROPORTION OF TOTAL EMPLOYMENT (Lk/L), AND OUTPUT PER WORKER (X/L)



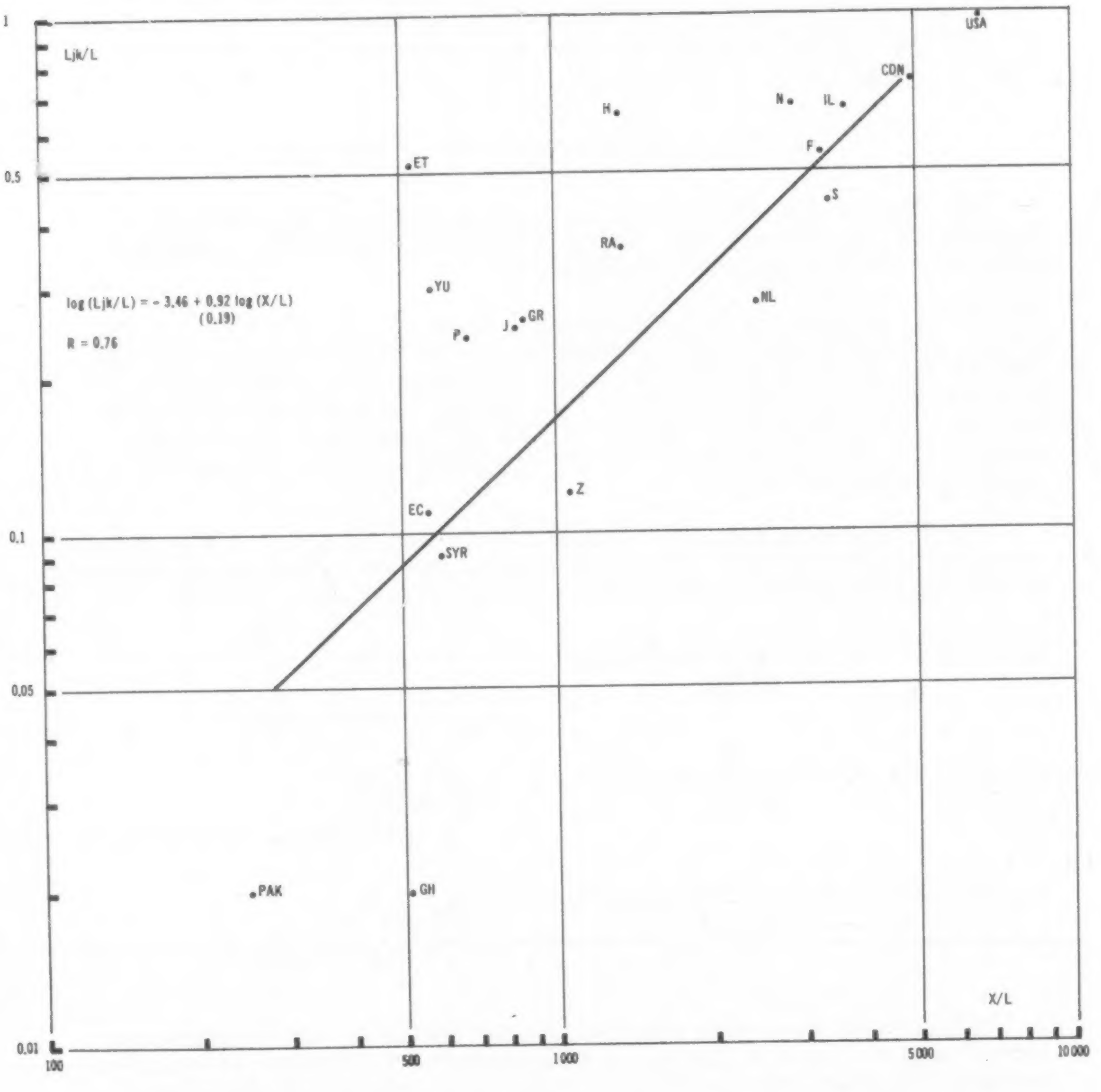
Graph III-11

NUMBER OF PERSONS WITH «UNIVERSITY DEGREE»,
AS A PROPORTION OF TOTAL EMPLOYMENT (Lk/L), AND OUTPUT PER WORKER (X/L)



Graph III-12

NUMBER OF «SCIENTIFIC AND TECHNICAL WORKERS» WITH A «UNIVERSITY DEGREE», AS A PROPORTION OF TOTAL EMPLOYMENT (Ljk/L), AND OUTPUT PER WORKER (X/L)



In short, a comparison of the correlations obtained for the different economic variables with Lk/L and then with Ljk/L shows that better correlations can only be obtained with the latter in certain well-defined cases. For other occupational categories with other levels of education, different explanatory variables would have to be used giving some indication of the level of social demand for education, the prevailing wage structure, etc.

3. MAIN ECONOMETRIC RELATIONSHIPS

We shall now attempt to select the most interesting equations in Table III-2, as regards both quality of correlations and the precision obtained for the regression coefficients. *

First, as regards the explanatory variables, while the use of one or the other may give different results, the differences are neither important nor systematic with regard to the correlation coefficients. The regression coefficients, however, are always highest for the (Ie) indicator and lowest for the "capital" ($\Sigma I/L$) indicator, the ratio being roughly 1.8 to 1, the elasticities for productivity (X/L) lying somewhere between the two.

Some equations linking the occupational structure with the economic variables are especially reliable because of the relatively small standard deviations attached to the regression coefficients; thus, we find:

$$\log (Lj/L) = -1.28 + \underset{(0.06)}{0.63} \log (X/L)$$

R = 0.90
N = 25
j = major group 0

$$\log (Lj/L) = -3.11 + \underset{(0.17)}{0.99} \log (X/L)$$

R = 0.82
N = 19
j = sub-groups 00/01/02/0X

$$\log (Lj/L) = -1.97 + \underset{(0.14)}{0.70} \log (X/L)$$

R = 0.73
N = 25
j = major group 1

These three equations confirm, on the one hand, the occupational redistribution within major group 0 in favour of scientific and technical workers for which the elasticity is equal to 1, and on the other hand, the faster growth in the "managerial" group than in the "professional" group.

$$\log (Lj/L) = -1.16 + \underset{(0.19)}{0.92} \log (Ie)$$

R = 0.71
N = 25
j = major group 1

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* It should be remembered that the latter are significantly different from 0 when they are considerably higher than twice their standard deviations in equations based on 20 to 30 observations, and more than 2.2 times the standard deviation in equations based on less than 20 observations.

$$\log (Lj/L) = -0.63 + \underset{(0.12)}{0.92} \log (Ie)$$

R = 0.84
N = 25
j = major group 2

The proportion of both groups in total employment rises at the same rate; it thus does not appear that the ratio of "number of clerical workers per manager" shows any sign of changing as economic development proceeds. However, the over broard definition of group 1 here precludes any very specific conclusions.

For the other occupational categories - technicians, sales workers, production process workers and craftsmen - the standard deviations are so high to render the elasticities obtained practically unusable.

If we now turn to the equations establishing a direct link between the educational structure of the labour force and the economic variables, it will be noted, first, that the coefficient of elasticity tends to become more precise as the level of education is extended; and next, that the elasticities are roughly equal for the three levels A, B and C with each of the explanatory variables considered: b shows little difference from 1.1, 0.80 and 0.60 with the Index, X/L and $\Sigma I/L$ respectively. If, therefore, the proportions of graduates rise at the same rate, as development proceeds, this means that the ratios between these different Lk/L's are constant. In other words, the numbers of graduates at the different levels would, in theory, be linked with each other by the same ratio in every country, if our correlation figures were perfect. *

Whatever approximations have led to these results, they give some idea of the rigidity of the educational structures; a country that is under-educated at university level will most likely be under-educated at secondary level, and vice versa. Our graphs already implied this: we found no examples of substitution between levels of education, in the sense that no country which is under-educated at university level was found above the line at secondary level.

This being so, the proportion with "eight years' schooling or less" is, as we have seen, very closely linked with productivity; the equation in log-linear form appears as follows:

$$\log (Lk/L) = 2.72 - \underset{(0.06)}{0.40} \log (X/L)$$

R = -0.85
N = 17
(see Graph III-10)

We shall now turn our attention to the results of the equations where Ljk/L is a dependent variable for each of the three levels of education A, B and C in turn: see Table III-2.

1. "University degree level or above". In the cases where significant results are obtained, the three explanatory variables yield correlations of very similar quality; major group 0 with $\Sigma I/L$ is, however, an exception. The (Ie) indicator is generally the most "sensitive" variable, with a regression coefficient higher than 1, whereas that for investment never rises as high as 0.75. With productivity, elasticity fluctuates

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* The ratio of the estimated values of two Lk/L's should be roughly constant.

between these two figures.* The precision of the elasticities varies according to the independent variable: the standard deviations oscillate around 20 and 25% of the regression coefficients for productivity and investment respectively.**

More specifically, the three regression coefficients are slightly higher for scientific and technical workers than for major group 0, which indicates a very slow redistribution of this group in favour of science graduates. The commonly held opinion that, in many countries, the shortage of scientific and technical workers is such as to hamper growth must here be qualified: it is quite clear that the numbers of non-scientific workers are growing in roughly similar proportions. This is confirmed by the analysis of the correlation coefficients for productivity and investment, in proceeding from the total for group 0 to scientific and technical workers. It might indeed have been thought that the countries giving a poor correlation for group 0 did so mainly because of a redundancy of "traditional" graduates (see Graph III-4); if, as is here the case, there is little improvement when only science graduates are taken*** (see Graph III-12), it can confidently be assumed that, in these countries, the redundancy refers to all graduates, scientists and non-scientists. This observation does not, of course, exclude an extreme diversity from country to country, having regard to the fact that as a whole, our correlations remain of very mediocre quality.

As regards major group 1, still at university graduate level, it will be seen that the correlation obtained with $\Sigma I/L$ is the same as with Ie, while the standard deviations are roughly equal for all three variables: 25% of the regression coefficient.

As examples, a few of the "best" equations obtained are shown below:

$$\log(L_{jk}/L) = -2.59 + \underset{(0.17)}{0.84}\log(X/L)$$

R = 0.73
N = 25
j = major group 0

$$\log(L_{jk}/L) = -3.46 + \underset{(0.19)}{0.92}\log(X/L)$$

R = 0.76
N = 19
j = sub-groups 00/01/02/0X

$$\log(L_{jk}/L) = -3.10 + \underset{(0.18)}{0.74}\log(\Sigma I/L)$$

R = 0.68
N = 22
j = major group 1

$$\log(L_{jk}/L) = -3.28 + \underset{(0.21)}{0.80}\log(X/L)$$

R = 0.63
N = 25
j = major group 1

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* Major groups 0, 1, 3, sub-groups 00/01/02/0X.

** At any rate, more precision is obtained than with Lk/L; the "détour" through certain occupational categories thus confers added precision on the calculation.

*** Strictly speaking only the numbers holding a science degree in major group 0 should be taken; but as can be seen in Annex A, few countries give a breakdown of their graduates into scientists and non-scientists. The number of scientific and technical workers (00/01/02/0X) holding degrees does, however, give a rough approximation.

It will be noted that the proportion of managerial workers (major group 1) increases at roughly the same rate as major group 0 as a whole, but rather more slowly than the proportion of scientists (00/01/02/0X).

2. "Completed secondary level or above". A quick look at the Ljk/L equations at this level shows that the variations in elasticities according to the occupational category considered are greater than at university level; here, the regression coefficients vary from 1 to 1.7 for Ie, from 0.7 to 1 for productivity (X/L), and from 0.5 to 0.8 for "capital" ($\Sigma I/L$).

For the three explanatory variables, the elasticities for "scientific and technical worker" are distinctly higher than those for major group 0; in that group, there will thus be a marked redistribution in favour of scientific workers, as development proceeds. As an indication of the order of magnitude, for Ie we get:

$$\log (L_{jk}/L) = -1.02 + \underset{(0.13)}{1.02} \log (Ie) \qquad R = 0.87,\; N = 21,\; j = \text{major group 0}$$

$$\log (L_{jk}/L) = -2.11 + \underset{(0.20)}{1.27} \log (Ie) \qquad R = 0.88,\; N = 14,\; j = \text{sub-groups 00/01/02/0X}$$

The progression in the "technicians" sub-group proper (0X) is, however, less rapid than in the other sub-groups (00/01/02), as can be seen from the following equation:

$$\log (L_{jk}/L) = -2.19 + \underset{(0.40)}{1.12} \log (Ie) \qquad R = 0.73,\; N = 9,\; j = \text{technicians (0X)}$$

Too much importance should not, however, be attached to the possible under-representation of technicians of secondary level or above, having regard to the well-known difficulties inherent in the very definition of the occupation of technician.

Lastly, executive and managerial workers (major group 1) show fairly good correlation with X/L, and their elasticity is roughly the same as for the scientific workers (00/01/02/0X):

$$\log (L_{jk}/L) = -3.03 + \underset{(0.16)}{0.91} \log (X/L) \qquad R = 0.79,\; N = 21,\; j = \text{major group 1}$$

$$\log (L_{jk}/L) = -2.94 + \underset{(0.16)}{0.88} \log (X/L) \qquad R = 0.85,\; N = 14,\; j = \text{sub-groups 00/01/02/0X}$$

In view of the above comments regarding numbers of manual workers and craftsmen with "completed secondary level or above"*, too much importance will not be attached to the relationships obtained in this case.

3. "More than eight years' schooling" level. It may here be noted that the proportion of executive and managerial workers tends to grow faster than the proportion of clerical workers, as shown by the following equations:

$$\log(Ljk/L) = -2.93 + \underset{(0.19)}{0.95} \log(X/L)$$

R = 0.80
N = 25
j = major group 1

$$\log(Ljk/L) = -1.86 + \underset{(0.09)}{0.77} \log(X/L)$$

R = 0.91
N = 17
j = major group 2

In other words, the ratio of executive and managerial workers to clerical workers with this level of education is tending to increase. This is probably due to the very wide definition of major group 1, which ranges from senior civil servants to small farm managers; if it were broken down into a few sub-groups with slightly more specific and standardized definitions, the analysis of this group's educational profile could be considerably refined.

Probably for the same reason, the elasticities for group 1 show a slight increase or remain the same as the level of education declines, while the opposite occurs for elasticities in group 0; this tends to show that the latter group is more and more strictly confined to the higher educational levels, while there is no decrease in the representation of the "lower" educational levels in the executive and managerial group.

The only really interesting results for the sales workers group were obtained at this level of education, with an elasticity between that for managerial workers and that for clerical workers:

$$\log(Ljk/L) = -2.51 + \underset{(0.18)}{0.85} \log(X/L)$$

R = 0.78
N = 17
j = major group 3

The elasticities for major group 7/8 (manual workers and craftsmen) are the highest for any of the occupational categories considered, whatever explanatory variable is chosen; for productivity, the following results are obtained**:

$$\log(Ljk/L) = -2.89 + \underset{(0.24)}{1.06} \log(X/L)$$

R = 0.75
N = 17
j = major group 7/8

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* See Graph III-7 and text.

** See Graph III-9.

This may seem surprising in view of what has been said about the make-up of our sample, which comprises, it will be recalled, a majority of developing countries where the educational level for group 7/8 is most likely to be low. However, bearing in mind the broad scope of this category (including, in many countries, 30% of the total active population), a high elasticity for the "more than eight years' schooling" level merely reflects the rapidly rising need for formal education, a need which rises with productivity, as well as the need for more foremen, overseers, etc. Here again, a more "refined" occupational disaggregation would serve a useful purpose.

4. MEAN YEARS OF SCHOOLING AND TECHNOLOGICAL INDICATORS

One criticism which can be made of such measurements as Ljk/L is that the percentages give a very incomplete indication of the level of education of any given group, as they leave out of account of relatively large proportion of the numbers included. It may, indeed, be asked whether the rather mediocre quality of certain correlations is not due to the fact that the Ljk/L's used represent partial educational inputs only.

To remedy this drawback, equations have been worked out which link the same technological indicators as in the previous paragraphs with the mean years of schooling for each occupational category and for the total labour force. These data, which involve some tedious calculations and some rather bold approximations, are taken from the Layard and Saigal study which moreover specifies that the same weight has been allotted to each year of schooling; thus one year of primary education has been considered the equivalent of one year at the university. *

The equations tested are in the following form:

$$\log (k_j) = \log a + b \log (n)$$

k_j being the mean years of schooling for category j, and n any one of the technological indicators.

The whole set of results will be found in Table III-3. Among other things, it will be noted that, as a rule, the correlation between k_t (mean years of schooling for the total active population) and the economic indicators is more precise ($0.67 < R < 76$, according to the independent variable considered) than that between k_j and the same variables; this is significant for major groups 1, 3, 4 and 5 only. **

Farmers constitute an exception, however, giving:

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* Some weighting by cost per year of schooling, for example, would have been welcome. It seems that the authors have not introduced any such weighting for lack of data. For this reason, we shall not attach the same importance to this type of measurement of the level of education, which is of little use for forecasting purposes, though it may be of some interest for comparing the educational stocks of two populations. Furthermore, most of the census data are largely inadequate for a reasonably accurate calculation of the mean years of schooling by occupations.

** Major groups 4 and 5 represent farmers and all other manual categories respectively.

Table III-3. SIMPLE REGRESSION EQUATIONS LINKING $\left\{\begin{array}{l}\text{the mean years of schooling of workers in occupational categories, } k_j\\ \text{the mean years of schooling of workers in total labour force, } k_t\end{array}\right.$

TO SOME GENERAL ECONOMIC INDICATORS

$$\left\{\begin{array}{l}\text{Index}\\ X/L\\ \Sigma I/L\end{array}\right. \quad \left.\begin{array}{l}\log k_j\\ \\ \log k_t\end{array}\right\} = \log a + b \log (n)$$

OCCUPATIONAL CATEGORIES		MEAN YEARS OF SCHOOLING (E)				OCCUPATIONAL CATEGORIES		MEAN YEARS OF SCHOOLING (E)			
		N	R	log a	b(σ b)			N	R	log a	b(σ b)
Major Group 0	Index	20	0.45	0.92	0.10(0.05)	Major Group 3	Index	20	0.63*	-0.22	0.65(0.19)
	X/L	20	0.40	0.86	0.07(0.04)		X/L	20	0.63*	-0.79	0.49(0.14)
	ΣI/L	18	0.41	0.90	0.06(0.03)		ΣI/L	18	0.53*	-0.26	0.33(0.13)
Major Group 1	Index	19	0.57*	0.66	0.20(0.07)	Major Group 4	Index	20	0.74*	-1.07	1.07(0.23)
	X/L	19	0.58*	0.44	0.17(0.06)		X/L	20	0.69*	-1.89	0.77(0.19)
	ΣI/L	17	0.64*	0.51	0.15(0.04)		ΣI/L	18	0.64*	-1.16	0.55(0.17)
Major Group 2	Index	19	0.30	0.84	0.09(0.07)	Major Group 5	Index	20	0.68*	-0.23	0.63(0.16)
	X/L	19	0.34	0.73	0.08(0.05)		X/L	20	0.67*	-0.78	0.47(0.13)
	ΣI/L	17	0.20	0.86	0.04(0.05)		ΣI/L	18	0.58*	-0.26	0.32(0.11)
						Total Labour Force	Index	20	0.76*	-0.41	0.75(0.15)
							X/L	20	0.74*	-1.04	0.56(0.12)
							ΣI/L	18	0.67*	-0.51	0.40(0.11)

$$\log(k_j) = -1.07 + \underset{(0.23)}{1.07} \log(Ie)$$

$R = 0.74$
$N = 20$
k_j = mean years of schooling for farmers.

Compared with:

$$\log(k_t) = -0.41 + \underset{(0.15)}{0.75} \log(Ie)$$

$R = 0.76$
$N = 20$
k_t = mean years of schooling for the total active population.

The elasticities for farmers are also the only ones that are higher than the elasticities for the total active population, whatever explanatory variable is used. This is probably due to the numerical importance of this group in the developing countries, and the "under-education" by which they are characterized. The high elasticities thus merely indicate that some leeway is being made up in the mean years of schooling for farmers as compared with the rest of the labour force, as growth proceeds.

The unsatisfactory results obtained for major group 0 may be due to the absence of any weighting of the years of education in calculating k_j: the more diversified the level of education in this group the wider the approximation.

The low correlations for clerical workers will also be noted; these should be compared with the good correlations obtained for the fraction of this group with more than eight years' schooling. It thus appears that the numbers in this group with "eight years' schooling or less" vary from country to country as determined by non-economic criteria.

XI

LEVELS OF EDUCATION OF THE OCCUPATIONAL CATEGORIES AND THE OCCUPATIONAL STRUCTURE OF EMPLOYMENT

The aim here is to link the educational level in the different occupational categories with the occupational structure (Lj/L) of employment, the idea being that the latter constitutes an acceptable substitute for the technological indicators used hitherto. It was thus brought out by the analysis in Part Two that fairly definite econometric links exist between Lj/L and the above-mentioned indicators, at the level of the economy as a whole.* Certain exceptions should however be noted: sales workers, technicians, craftsmen and production process workers in particular, for which categories some research is needed with other explanatory variables. There are thus two distinct phases in the analysis of the educational levels of the different occupational categories: determination of the occupational structure, using economic or other variables, and determination of the levels of education on the basis of the relative size of each occupational category.

There is a second advantage in substituting the occupational structure of employment for the technological indicators: the explanatory variable then becomes a percentage related to total employment in the same way as the dependent variable, and the errors of observation which affected the indicators are thus replaced by the errors affecting Lj/L - largely the same as those affecting Ljk/L.

At the same time, however, high rates of correlations can clearly be expected between Ljk/L and Lj/L, since the first percentage is included in the second. Furthermore, the correlations will tend to improve as the level of education considered expands, since Ljk/L will then gradually draw closer to Lj/L.

It can be assumed that the level of education within given occupational groups depends partly on the weight or size of that group in relation to the total labour force. Although the correlation coefficients obtained may be largely artificial, the elasticity coefficients are of undoubted value in this context, precisely because they give us an indication as to the redistribution (or deployment) of the qualified manpower within each occupational category, when the weight of this occupational category changes.

The equations linking the level of education of the different occupational categories and the occupational structure of employment will be in the form:

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* See also Table III-2.

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$$\log (Ljk/L) = \log a + b\ (Lj/L)$$

The full set of results will be found in Table III-4.

It may be wondered why we have omitted the dependent variable Ljk/Lj in this case. The reason is very simple: there is no need to test Ljk/Lj = f (Lj/L) and Ljk/L = f (Lj/L) in succession, because the three percentages are tautologically linked. We find, indeed: Ljk/Lj = (Ljk/L) . (L/Lj).

As a result, the parameters of the two equations in double-logarithmic form are linked by the following rigid relationships:

- the regression coefficient of the first equation is always equal to that of the second, minus 1;
- the constant of the first equation is always equal to the second, plus 2.*

This being clear, Table III-4 shows that excellent correlations are obtained between Ljk/L and Lj/L in many cases, as expected: thus R exceeds 0.90 for major group 0 at the "completed secondary" and "more than eight years' schooling" levels; for major groups 1 and 2 at "more than eight years' schooling" level; and for major groups 3 and 7/8 at "eight years' schooling or less" level.

Improvement in the correlation as the level of education considered expands seems to confirm the existence of artificial correlations, even though the size of the samples varies appreciably.

Investigation of the elasticities will be facilitated if the following points are borne in mind:

1) an elasticity close to 1 between Ljk/L and Lj/L signifies that Ljk/Lj tends to remain constant because of the tautological relationship linking the three percentages;
2) an elasticity higher or lower than 1 signifies that Ljk/Lj tends to rise or fall for the same reason;

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* Starting with the identity:

1. $Ljk/Lj \equiv (Ljk/L) . (L/Lj) . 100$

which may be written

2. $\log (Ljk/Lj) \equiv \log (Ljk/L) - \log (Lj/L) + \log 100$

On the other hand, the two equations may be written as follows:

3. $\log (Ljk/L) = \log a_o + a_1 \log (Lj/L)$
4. $\log (Ljk/Lj) = \log b_o + b_1 \log (Lj/L)$

If equations 3 and 4 are introduced into identity 2, we obtain:

5. $\log b_o + b_1 \log (Lj/L) \equiv \log a_o + a_1 \log (Lj/L) - \log (Lj/L) + 2$

which may be written:

6. $\log b_o + b_1 \log (Lj/L) \equiv \log a_o + 2 + (a_1 - 1) \log (Lj/L)$

If expression 6 is to stay an identity, we have:

$$\log b_o = \log a_o + 2$$
$$b_1 = a_1 - 1$$

Table III-4. SIMPLE REGRESSION EQUATIONS LINKING THE LEVELS OF EDUCATION OF OCCUPATIONAL CATEGORIES (Ljk/L) TO THE OCCUPATIONAL STRUCTURE OF TOTAL LABOUR FORCE (Lj/L)

$$\log (Ljk/L) = \log a + b \log (Lj/L)$$

	DEGREE LEVEL AND ABOVE (A)				COMPLETE SECONDARY SCHOOLING AND ABOVE (B)				MORE THAN EIGHT YEARS OF SCHOOLING (C)				EIGHT YEARS OF SCHOOLING OR LESS (D)			
	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)
OCCUPATIONAL CATEGORIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Major Group 0	25	0.79*	-0.89	1.29(0.21)	21	0.94*	-0.41	1.27(0.11)	17	0.97*	-0.22	1.15(0.07)	17	0.29	-0.47	0.47(0.40)
Minor Groups 00/01/02/0X	19	0.84*	-0.55	0.83(0.13)	14	0.88*	-0.21	1.04(0.16)								
Minor Group 0X ..	12	0.35	-1.64	0.59(0.50)	9	0.89*	-0.29	1.10(0.21)								
Major Group 1	25	0.77*	-1.01	1.03(0.18)	21	0.88*	-0.43	0.96(0.12)	17	0.96*	-0.29	1.09(0.08)	17	0.85*	-0.42	0.96(0.15)
Major Group 2	25	0.56*	-1.81	1.08(0.34)	21	0.69*	-0.62	1.10(0.26)	17	0.93*	-0.22	1.00(0.10)	17	0.75*	-0.45	0.92(0.21)
Major Group 3	25	0.40	-2.06	0.79(0.37)	21	0.32	-0.76	0.58(0.39)	17	0.56*	-0.48	0.75(0.29)	17	0.91*	-0.37	1.23(0.15)
Major Groups 7/8 .					21	0.36	-1.36	0.83(0.50)	17	0.55*	-0.76	0.88(0.35)	17	0.96*	-0.48	1.28(0.10)

3) to be satisfactorily compared, the elasticities should preferably be related to the same explanatory variable Lj/L. Our comments will therefore refer to "horizontal" comparisons within each occupational group: see Table III-6. The relative values of the elasticities should give us an idea of the trend within the educational profile for each occupational category (Ljk/Lj).

Thus, for major group 0, the elasticities for the three educational levels A, B and C are distinctly higher than 1; the proportion with a D-level education in this group will thus tend to decrease. In addition, the elasticities at "university degree" and "completed secondary or above" level are roughly the same (b = 1.3), and higher than that for the "more than 8 years' schooling" level (b = 1.15). This means that:

a) in this group, when k represents "university degree" level, Ljk/Lj rises at the same rate as when k represents "completed secondary level or above", i.e., 0.3%, whenever Lj/L increases by 1% and Ljk/L by 1.3%;

b) that the two previous Ljk/Lj's increase twice as fast as Ljk/Lj when k represents "more than eight years' schooling"; the latter in fact rises by 0.15% whenever Lj/L rises by 1% and Ljk/L by 1.15%.

In plain language, the "university degree level" and the "completed secondary level or above" are assuming increasing importance in the educational profile of professional and technical workers, though it is impossible to say that one is growing faster than the other. On the other hand, the proportion at both levels is increasing twice as fast as the proportion with "more than eight years' schooling". Only the proportion with "eight years' schooling or less" tends to fall.

As regards scientific and technical workers (00/01/02/0X), the elasticity of 0.83 at "university degree level" means that Ljk/Lj diminishes at this level; at secondary level, the elasticity is close to 1, meaning that Ljk/L and Lj/L increase at the same rate, or that Ljk/Lj remains roughly constant. These are indications of the fact that the number of middle-level technicians rises faster as the relative size of the scientific and technical workers' group increases.

This seems to be confirmed by the elasticity higher than 1 obtained for the technicians' sub-group (0X) at "completed secondary level or above": Ljk/Lj rises by 0.10% whenever Lj/L rises by 1% and Ljk/L by 1.1%.

For major group 1, the four elasticities do not greatly depart from 1, except at the "more than eight years' schooling" level: b = 1.10; Ljk/Lj will thus be constant at levels A and B, and will rise slightly at level C. It should therefore diminish at level D.* There is nothing particularly surprising about these results: a large though varying proportion of "managerial and executive workers ..." consists of small businessmen with one or two employees and their inclusion obviously tends to lower the general educational profile of this category, for which, we repeat, some further disaggregation would not come amiss.

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* It must be remembered that the "more than eight years' schooling" (k_1) and "eight years' schooling or less" (k_2) levels of education are mutually exclusive; if one is determined, the other is residually obtained, as $Ljk_1/L + Ljk_2/L = Lj/L$. The two can, therefore, be employed alternatively, but not successively.

In view of the above situation, it is hardly surprising that the educational profile of the clerical workers' group should evolve more favourably than that of the "managerial ..." group: elasticity is roughly equal to 1.10 at "university" and "secondary" levels (Ljk/Lj rises at those levels), and equal to 1 at the "more than eight years' schooling" level (Ljk/Lj constant). In actual fact, Ljk/Lj should increase at this level too, as it diminishes at the "eight years' schooling or less" level ($b = 0.9$).* This stratification of clerical workers by levels of education may indicate the growing need for responsible personnel in this group as it assumes more weight in the labour force.

The education profiles of sales workers and craftsmen and production workers follow a similar trend: the elasticities at the three levels A, B and C are all less than 1. At the "eight years' schooling or less" level, on the other hand, b is approximately equal to 1.25: Ljk/Lj at this level thus rises by 0.25%, whenever Lj/L rises by 1% and Ljk/L by 1.25%. Thus, the proportion of those with "eight years' schooling or less" rises in both groups as Lj/L increases.

These results should not be considered surprising when it is remembered that Lj/L is not correlated with the economic development indicators in the case of "sales workers" ($0.22 < R < 0.33$), and that moreover, the correlations obtained for "manual workers and craftsmen" are extremely mediocre ($0.44 < R < 0.58$).

Consequently, to say that the educational profiles of these categories become increasingly unfavourable as Lj/L rises does not mean that they also do so as economic development proceeds. In other words, the postulate on which this section rests is not here confirmed: Lj/L cannot be employed as a substitute for the technological indicators.

In the case of sales workers, the fact that Ljk/L rises faster than Lj/L is certainly due to the high representation of the developing countries in our sample.** In those countries, the numbers in these groups are likely to be greatly swollen by a more or less illiterate labour force arriving from the country: street sellers, craftsmen, jobbing workmen, etc. To eliminate awkward results, the sample should be split into two: on one side, countries where these categories obviously act as a container for casual or part-time labour, and, on the other, countries where such structural employment problems no longer exist. The few observations at our disposal unfortunately prevented us from adopting this solution.

A more qualified interpretation will have to be adopted in the case of craftsmen and production workers. Grap III-8 above indicates that Lj/L is only correlated with the technological indicators in the first stages of development; from the $1,000 productivity level, Lj/L becomes fairly stable, fluctuating only between 25 and 35% of the labour force.

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* This is only an apparent contradiction; coherent elasticities for the "more than eight years' schooling or less" levels are perfectly conceivable, by manipulation of the standard deviations.

** Only four industrial countries are taken into account at this level of education: Canada, the United States, Israel and Puerto Rico.

- For countries with $X/L < \$ 1,000$, Ljk/L rises faster than Lj/L at the "eight years' schooling or less" level; the educational profile (Ljk/Lj) becomes more and more unsatisfactory as development proceeds. This is the stage at which a working class is constituted, with the emphasis on numbers of relatively uneducated people.
- For countries with $X/L > \$ 1,000$, Lj/L remains fairly constant, so that Ljk/Lj will rise only to the extent that Ljk/L rises: see the tautological relationship mentioned above. But Ljk/L is closely correlated with Lj/L ($R = 0.96$); it will thus also tend to remain constant.

*
* *

In our analysis of the relationship between levels of education of the different occupational categories and the occupational structure of employment, there only remains to say a few words about the links between the mean years of schooling in each category (k_j) and the occupational structure (Lj/L).

The equation used to test these relationships is in the form:

$$\log (k_j) = \log a + b \log (Lj/L),$$

and the only interesting results obtained were in the farmers category, for which we found:

$$\log (k_j) = 1.87 - \underset{(0.22)}{0.93} \log (Lj/L) \qquad R = -0.71 \quad N = 20$$

with Lj/L closely linked to the development indicators, especially productivity:

$$\log (Lj/L) = 3.91 - \underset{(0.07)}{0.79} \log (X/L) \qquad R = -0.93 \quad N = 20$$

As X/L increases, agricultural employment declines, in accordance with certain familiar concepts; and as Lj/L declines, the mean number of years of schooling for this category increases. This may seem paradoxical, as it is known that the move from the land is largely confined to the younger age groups, which are also the best educated; k_j should therefore decline. In actual fact, its diminution is more than offset by the increase in the mean years of schooling of the total labour force as development proceeds. * And as we shall see in the next chapter, this leads to a still faster increase in the mean level of education for farmers.

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* See p. 139 et seq.

A short summary of the analysis carried out in the three preceding chapters may be helpful, as the diversity of the results given may have somewhat obscured the problem.

While our final aim is indeed to arrive at Ljk in absolute figures, we have put forward three possible ways of doing so, not all of equal interest:

1. The first consists in linking the educational profile of the different occupational categories to the development indicators: $Ljk/Lj = f(n)$. We have seen that these results did not indicate very significant statistical relationships. Possible reasons and opinions concerning these results were presented at the end of Chapter IX.

2. The second consists in linking levels of education in the different occupational categories with the development indicators: $Ljk/L = f(n)$. The results are distinctly better than those previously obtained, but still vary appreciably according to the occupation or level of education considered. In most cases, moreover, the indicators do not account for a certain fraction of the variance of Ljk/L.*

3. The third method consists in dividing the problem into two stages: taking advantage of the fact that very good $Lj/L = f(n)$ correlations are obtained, at least for certain categories**, the occupational structure was taken as known, and $Ljk/L = f(Lj/L)$ was tested. This method, which has the advantage of agreeing more closely with the manpower approach in determining the quantitative aims of educational planning, can of course only be used when the occupational structure is known. In addition, this relationship has also given us insights into the redistribution (or deployment) of school leavers and graduates within each occupational category, when the relative importance of this occupational category changes.

* In the preceding chapters, we have restricted ourselves to simple regression analyses. Some multiple and step-wise regression equations will be presented in Annex B. However the introduction of a second technological indicator as an explanatory variable does not modify the conclusions presented here.

** See Part Two or Part Three, Chapter X, Table III-2.

XII

LEVELS OF EDUCATION OF THE DIFFERENT OCCUPATIONAL CATEGORIES AND EDUCATIONAL STRUCTURE OF THE TOTAL LABOUR FORCE

We saw in the previous chapter that levels of education of the different occupational categories and/or of the total labour force in some cases bore no very rigid relationship to the indicators of economic development. In most instances, a varying fraction of the variance in the former remained "unexplained" by the latter. It therefore seemed logical to look for variables of a different nature to account for the trend of levels of education by occupations.

It appeared to us, for example, that the "output" of the educational system over a long period, that is to say, the "supply" of qualified manpower at every level, played an important part in determining the educational profiles of the different occupational groups. These will thus naturally tend to take in more manpower with a certain level of qualifications than is strictly necessary*, if it is in relatively plentiful supply on the labour market. This "distortion" may or may not mean that this manpower will be paid less, according to whether or not wages are fixed in accordance with the traditional rule of marginal productivity.

Conversely, if certain types of qualified manpower are scarce on the labour market, the educational profiles of the different occupational categories will be adjusted accordingly, and the wage levels of such qualified manpower may rise.

In this chapter we shall, therefore, try to bring out the links between the "supply" from the educational system and the level of education of the different occupational categories, leaving the economic indicators out of account. Any reference to wages will unfortunately have to be excluded; it is common knowledge that we lag far behind in the matter of international wage statistics as related to levels of education.

1. INTRODUCTION

We shall ignore, for the time being, the economic variables introduced in the analyses in the previous chapter, and concentrate on the occupation/education matrix alone which contains all the elements of the problem, provided a few conventions are accepted.

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* I.e., more than the "needs" of the economy alone would suggest.

We referred above to the supply of qualified manpower from the educational system: strictly speaking, this supply equals the whole output of qualified and unqualified manpower produced by the system for more than half a century back*, allowing for death, disablement and emigration. The supply could be fairly accurately reconstituted in countries which have sufficiently long statistical series on the output of the educational system, as well as reliable mortality tables. In actual fact, such calculations are really feasible in very few countries**; in any event, they all demand the collection of data that lie beyond the confines of this study.

We shall, therefore, have to be satisfied with a more restricted notion of the "supply" of qualified manpower, taking into account only the numbers included in the education/occupation matrices as such. Our assumption will therefore be that the rates of activity applied to the aggregate number of qualified workers at each level are sufficiently comparable from country to country to avoid any major distortions in measuring the "supply". This proposition may cause surprise, since we know that rates of activity are precisely considered to result from the confrontation of job supply with demand. Upon taking a closer look, however, it seems clear that rates of activity for men are roughly the same (close on 100%) for most age groups; the only marked differences are found in the younger groups, and are related to length of schooling.

While this, of course, does not mean that there is no under-employment, especially in the developing countries, it can be claimed that the census figures cover the immense majority of the male population of working age, even if a certain fraction is insufficiently or unsatisfactorily employed. Rates of activity also depend on the level of education attained, which strengthens the previous argument: the immense majority of educated men of working age engage in some occupation, and the higher the level of education the closer the approximation. We repeat that this does not exclude a variable proportion of part-time or unsuitable employment at every level.

Rates of activity for women depend at one and the same time on age, level of education and all sorts of psycho-social factors which we need not dwell upon here, with the rates varying widely from country to country. We can only say in justification of our assumption that as the level of education rises the variations narrow: almost the same proportion of women graduates can be presumed to be active in a developing country as in an industrialized country. Conversely, the low rates of activity for women in the low-income countries match the marked under-education of the female population. Very broadly, our assumption is thus tentamount to saying that illiteracy among women is the chief cause of the variations in their rates of activity; the analysis which follows thus pays special attention to the levels of education at which the supply of labour can be most accurately measured; i.e., the higher levels.

One last argument arises out of the very nature of the process we want to define. The assumption is that the output of the educational system is somewhat inelastic, and that the same numbers of qualified people are poured into the labour market every year, regardless of the prevailing economic situation. The market must, therefore, be affected in one way or another by the "impact" of the system, and suffer some distortion as a result. Our object here is to confirm the existence of a common pattern of distribution of the system's output at every level in the various occupational categories, and while allowing for the reservations expressed above, we think that the occupation/education matrices contain the necessary data to test this assumption.

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* It being assumed that a person qualifying at the age of 15 can still form part of the potential supply of qualified manpower at the age of 65.

** But see the calculations made in the Netherlands, an example of which is given in The Educational Structure of the Labour Force, Chapter 2: "The graduate accumulation method", pages 7 and seq. In France, see the IEDES study already quoted: L'éducation de la population française et son évolution de 1850 à 1980.

The aggregate output to be distributed among the occupational groups will be represented, in each country, by the different values of Lk/L; the levels of education of the different occupational categories will be successively symbolized, as in the previous chapter, by Ljk/L and Ljk/Lj.

The equations we shall test will be in the following form:

$$\log (Ljk/L) = \log a + b \log (Lk/L)$$

$$\log (Ljk/Lj) = \log a + b \log (Lk/L)$$

All the results are to be found in Table III-5; the most significant will be analysed in the Section 2.

The average level of education of each occupational group was also tested in relation to the average level for the total labour force, using the equation:

$$\log (k_j) = \log a + b \log (k_t)$$

where k_j represents mean years of schooling in category j, and k_t, mean years of schooling in the total labour force.

2. ANALYSIS OF THE RESULTS

We shall first say a few words about the equations in the form Ljk/Lj = f (Lk/L) which bring out the incidence of the educational structure on the educational profile of the different occupational categories, allowing for variations in the occupational structure (Lj/L). We shall then make a more exhaustive analysis of the distribution relationships in the form Ljk/L = f (Lk/L). Just as we suggested that "horizontal" comparisons should be made between correlations or elasticities in reading Table III-4, it will be of value here also to compare the distribution elasticities "vertically", i.e., within each level of education (Lk/L): see Table III-5.

i) Educational profile of the different occupational categories and educational structure of the labour force

It is worth noting, for the first time in this study, that equations having Ljk/Lj as a dependent variable yield some meaningful results.

Table III-5. SIMPLE REGRESSION EQUATIONS LINKING THE LEVELS OF EDUCATION OF OCCUPATIONAL CATEGORIES (Ljk/Lj and Ljk/L) TO THE EDUCATIONAL STRUCTURE OF TOTAL LABOUR FORCE (Lk/L)

$\log (Ljk/L) = \log a + b \log (Lk/L)$; $\log (Ljk/Lj) = \log a + b \log (Lk/L)$

OCCUPATIONAL CATEGORIES		DEGREE LEVEL AND ABOVE (A)				COMPLETE SECONDARY SCHOOLING AND ABOVE (B)				MORE THAN EIGHT YEARS OF SCHOOLING (C)				EIGHT YEARS OF SCHOOLING OR LESS (D)			
		N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Major Group 0	Ljk/L	25	0.97*	-0.19	0.99(0.05)	21	0.90*	-0.19	0.73(0.08)	17	0.93*	-0.34	0.75(0.08)	17	0.10	-0.75	0.31(0.83)
	Ljk/Lj	25	0.83*	1.22	0.54(0.08)	21	0.85*	1.53	0.28(0.04)	17	0.71*	1.70	0.16(0.04)	17	0.56*	-2.26	1.83(0.69)
Minor Groups 00/01/02/0X	Ljk/L	19	0.92*	-0.80	1.04(0.11)	14	0.76*	-0.82	0.70(0.17)								
	Ljk/Lj	19	0.38	1.41	0.25(0.15)	14	0.55	1.56	0.24(0.11)								
Minor Group 0X	Ljk/L	12	0.63	-1.95	0.91(0.35)	9	0.73*	-1.14	0.72(0.20)								
	Ljk/Lj	12	0.39	0.30	0.54(0.40)	9	0.77*	1.38	0.35(0.11)								
Major Group 1	Ljk/L	25	0.87*	-0.98	0.98(0.12)	21	0.88*	-1.06	0.95(0.12)	17	0.92*	-1.39	1.18(0.13)	17	-0.48	3.19	-1.79(0.84)
	Ljk/Lj	25	0.41	0.95	0.30(0.14)	21	0.30	1.42	0.16(0.11)	17	0.36	1.57	0.14(0.09)	17	0.35	0.29	0.68(0.47)
Major Group 2	Ljk/L	25	0.80*	-1.21	1.12(0.17)	21	0.91*	-0.83	1.13(0.12)	17	0.94*	-0.49	0.85(0.08)	17	-0.15	1.06	-0.46(0.76)
	Ljk/Lj	25	0.48	0.16	0.56(0.21)	21	0.55*	1.01	0.49(0.17)	17	0.41	1.62	0.14(0.08)	17	0.63	-0.85	1.25(0.39)
Major Group 3	Ljk/L	25	0.81*	-1.61	1.11(0.17)	21	0.86*	-1.45	1.26(0.17)	17	0.90*	-1.13	1.05(0.13)	17	0.02	0.47	0.05(0.90)
	Ljk/Lj	25	0.75*	-0.37	0.94(0.18)	21	0.73*	-0.03	1.04(0.22)	17	0.64*	0.60	0.64(0.20)	17	0.61*	0.00	0.96(0.32)
Major Groups 7/8	Ljk/L					21	0.89*	-1.85	1.73(0.21)	17	0.93*	-1.30	1.41(0.14)	17	-0.24	2.76	-0.88(0.92)
	Ljk/Lj					21	0.68*	-0.70	1.24(0.31)	17	0.64*	0.15	0.81(0.25)	17	0.30	1.11	0.41(0.33)

Generally speaking, it can be said that distinctly better fits are obtained with the form Ljk/Lj = f (Lk/L) than with Ljk/Lj = f (n)*, which, it will be remembered, rarely gives significant correlations.

Returning to the same example, comparing major group 0 with "completed secondary level or above" in the Netherlands and Greece**, it will be seen that, this time, the ratio Ljk/Lj, which is higher in Greece (80%) than in the Netherlands (60%) coexists with the same Lk/L ratios for both countries - 11% - although productivity in Greece is much below that in the Netherlands. It can thus be seen how the relative abundance of Lk in a low-productivity country allows better fits for Ljk/Lj = f (Lk/L).

It will be recalled that we had some reservations to make concerning the utilization of the ratio Ljk/Lj correlated with the economic variables, as this ratio may be high in certain low-productivity countries because Lj is artificially low (not because Ljk is too high). Judging by certain correlations in Table III-5, which are as high with Ljk/Lj as with Ljk/L***, these high values for Ljk/Lj must correspond to high values for Lk/L.

This situation is, however, far from general. It should thus be noted that while correlation between Ljk/Lj and Lk/L is significant for categories 0, 0X, 3 and 7/8, practically no significant coefficient emerges at the level of categories 1 and 2. It might have been thought that the administrative workers' and clerical workers' groups should have recorded most of the thrust from the potential supply of graduates produced by the educational system, so wide is the definition of these categories, and so variable the standard of education of their members. In the case of major group 1, the distortions mentioned in the measurement of Lj undoubtedly have some effect; thus, at "completed secondary level or above", the ratios Ljk/Lj are practically the same in Japan and in the United States (67 and 69% respectively), while Lk/L is considerably higher in the United States (47 compared with 30%), and Lj/L is nearly three times as high (6.3 compared with 2.3%). The pattern is less widespread for the clerical workers' category: in the Netherlands, Israel and Argentina, practically the same proportion of the labour force has "completed secondary level or above" - Lk/L = 10-12%; furthermore, between 11 and 12% of the manpower in these three countries consist of clerical workers (Lj/L). On the other hand, while the ratios Ljk/Lj are comparable as between the Netherlands and Israel (18 and 15% respectively), the ratio approaches 30% for Argentina - twice as high as that for Israel. As this difference can be explained neither by the occupational structure, nor by the impact from the educational system, (which is similar in both countries), it must be recognized that the propensity of people with secondary qualifications to hold clerical jobs may differ from country to country for reasons unconnected with the scale of growth of the educational system.

With these reservations, it will be noted that the correlation coefficients for Ljk/Lj decline sharply as the standard of education falls off, especially in major groups 0 and 3 (lines 3 and 16 respectively). This should probably be related to the narrow definition we adopted for supply. For low standards of education, a variable fraction of supply has already been accounted for by the different rates of activity in different countries, and our Lk/L thus give a rather unsatisfactory indication of the push from the educational system; at the higher levels of education, on the other hand, any distortions caused by the supply of qualified manpower are liable to "rectify" the educational profile of the occupational categories required in accordance with the economic indicators.

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* See Table III-1.

** See Chapter IX.

*** At "completed secondary level or above", major group 0 and technicians, for example.

The elasticities of the equations Ljk/Lj = f (Lk/L) are higher for the categories with a less impressive educational profile ("sales workers", "manual workers and craftsmen") than for the highly educated (major group 0); this is natural, as in the latter case, the Ljk/Lj ratios are sometimes close to 100.

Interference from the variations in Lj/L thus appreciably complicates the interpretation of the results; we shall, therefore, make a more detailed analysis of the distribution elasticities offered by the equation Ljk/L = f (Lk/L) in the following paragraph.

ii) Levels of education for the different occupational categories and educational structure of the labour force

a) University degree level or above. The correlation coefficients (R) are particularly high, especially for major group 0 and for scientific and technical workers: 0.97 and 0.92 respectively. The correlations of Ljk/L with Lk/L are in every case higher than those obtained with the economic variables*; this is particularly striking as one moves down the occupational ladder (major groups 1, 2 and 3). A conclusion, it will be remembered, was that the presence of university graduates in these groups, especially in 2 and 3, was also due to factors other than specifically economic "needs". It is interesting to note how closely the percentage of university graduates in these groups is associated with the proportion of graduates in the total labour force.** In short, we find here a particularly clear tendency on the part of the educational system to release its university graduates into these occupational groups.

With regard to the coefficients of elasticity, a significant point is that they are almost equal to 1 for groups 0 and 1, and slightly higher for groups 2 and 3: 1.10. These slight "overtaking movements" in relative terms - which represent considerable differences in absolute figures - show that, when there is a larger stock of university graduates available in the total labour force, a larger number flow into the sales and clerical workers categories than into the professional or managerial occupations.

There may be several reasons for this: the position may reflect a relative saturation of major group 0, which can absorb no more university graduates, coinciding with a preponderance of older age groups in major group 1 (few people become "managers" at 25). Or the reason may be that arts graduates find no employment open to them other than clerical work. It may here be noted that the elasticity for science graduates (00/01/02/0X) lies midway between those for managerial workers and clerical workers: 1.04.

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* See Table III-2.

** Especially as artificial correlations are less likely to arise here than in the Ljk/L = f (Lj/L) fits, since the values of Ljk/L which we compare correspond to the different occupational groups at one level of education and hence are not cumulative.

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The standard deviations in the regression coefficients, which range from 5% (for major group 0) to 15% (for groups 2 and 3) of the value of the coefficients, suggest, however, that some caution should be observed.

This being granted, our best equation at "university degree level or above" will undoubtedly be:

$$\log (Ljk/L) = -1.19 + \underset{(0.05)}{0.99} \log (Lk/L)$$

$R = 0.97$
$N = 25$
j = major group 0

b) Completed secondary level or above. Here again the correlations between Ljk/L and Lk/L are better than those obtained for the economic variables, with a few important exceptions; these are largely the same for major group 0 and for technicians; and the correlations between Ljk/L and the economic variables are better for scientific and technical workers (00/01/02/0X). That the level of education for this category should be more strictly linked with the economic variables than with the stock of graduates available at this level may not be due to mere coincidence.

Is this how we should interpret the coefficients of elasticity, which are the same for all three groups ($b = 0.70 - 0.75$), and distinctly lower than for the other groups ? Yes, in the sense that the flow of "completed secondary levels" into the former would be limited by their relatively hard-and-fast links with, say, X/L, and the surplus graduates available would then turn to groups 2, 3 and 7/8, for which the elasticities are much higher than 1.

Elasticity is particularly high for the "manual workers and craftsmen" group: 1.73. It no doubt corresponds to the requirements of supervisory staff in this category, which should easily be able to absorb manpower of "completed secondary level or above" as the proportion of such manpower increases in the total labour force.

Having regard to the size of the standard deviations, our best two equations will be:

$$\log (Ljk/L) = -0.19 + \underset{(0.08)}{0.73} \log (Lk/L)$$

$R = 0.90$
$N = 21$
j = major group 0

$$\log (Ljk/L) = -0.83 + \underset{(0.12)}{1.13} \log (Lk/L)$$

$R = 0.91$
$N = 21$
j = clerical workers

The elasticities in these equations illustrate with some clearness the uneven deployment of manpower with secondary qualifications in two different occupational groups.

c) More than eight years' schooling level. The correlation coefficients at this level are all equal to or higher than 0.90, which is not particularly surprising. The "push" of the educational system can be expected increasingly to affect all occupational categories as we move down the educational scale.

Here again elasticities tend to be higher at the bottom of the occupational ladder. Major group 1 constitutes a shining exception, however: its elasticity of 1.2 is exceeded only by that of the "manual workers and craftsmen" group (b = 1.4). The fact that this group strongly reacts under the impact of the educational system, especially at this level, is another measure of the variety of occupations it includes; the result is no doubt due to small, independent businessmen, who leave school to enter the labour market after receiving a general education going a little beyond the primary cycle.

It will also be noted that the elasticity for clerical workers is distinctly lower than 1, unlike the position at higher levels of education. At such a level of education, this occupational group takes only fourth place in absorbing the available stock. It takes a little more than its "fair share" at "completed secondary level or above" (b = 1.13), and a little less at the "more than eight years' schooling" level (b = 0.85).

The coefficients of elasticity are, moreover, fairly accurate; in some cases, the standard deviations do not exceed 10% of the regression coefficient:

$$\log (Ljk/L) = -0.49 + \underset{(0.08)}{0.85} \log (Lk/L) \qquad R = 0.94 \quad N = 17 \quad j = \text{major group 2}$$

$$\log (Ljk/L) = -1.30 + \underset{(0.14)}{1.41} \log (Lk/L) \qquad R = 0.93 \quad N = 17 \quad j = \text{major group 7/8}$$

Here again there is high elasticity for "manual workers and craftsmen"; this confirms the position noted for "completed secondary level or above", and certainly corresponds to this category's requirements for supervisory staff.

d) Eight years' schooling or less level. No significant result is obtained at this level. There seems to be no common model showing the distribution of manpower at this level among the different occupational groups. In no group is the proportion with this level of education related to the proportion of those people in the total labour force.

This absence of any significant relationship between Ljk/L and Lk/L should be considered in conjunction with the non-significant relationships obtained between Ljk/L and the economic development indicators: see Chapter X.

e) Mean years of schooling. Here more interesting results are obtained. All the correlations are better than those obtained for the economic variables, and they are also excellent for the groups with the largest and least educated work force; thus we obtain:

$$\log (k_j) = 0.05 + \underset{(0.07)}{0.99} \log (k_t) \qquad R = 0.96 \quad N = 20 \quad j = \text{sales workers}$$

$$\log(k_j) = -0.50 + \underset{(0.06)}{1.45} \log(k_t)$$

R = 0.99
N = 20
j = farmers

$$\log(k_j) = 0.07 + \underset{(0.06)}{0.90} \log(k_t)$$

R = 0.97
N = 20
j = all manual workers except farmers

Here the correlations are distinctly better than in $k_j = f(n)$; the "push" factors apparently play a more important role than the "pull" factors as expressed by our economic variables. The level of education in these categories is more closely related than that of other categories to the mean level of education for the whole labour force, and this is intuitively acceptable when it is known that these groups are the least highly educated and the last to be "served" in the matter of education.

This applies in particular to "farmers", the only group with an elasticity higher - much higher - than 1*, which seems to indicate that the level of education in this group goes some way towards overtaking that in the other groups as the mean level of education in the total labour force improves.

At the same time, owing to the absence of weighting of the years of schooling in calculating k_j and k_t, and to the composition of our sample, dominated by countries where 90% of the active population has not gone beyond the primary level, the improvements in k_t, in fact, mirror the lengthening and/or introduction of compulsory education over a certain period.

While the "sales workers" group maintains its mean level of education in relation to the rest of the active population, the same cannot, unfortunately, be said of manual workers other than farmers, of which "production process workers and craftsmen" and "service workers" form the largest groups; their elasticity remains, indeed, distinctly lower than 1.

For categories 0, 1 and 2, the correlations are only mediocre, and the elasticities all lower than 0.25; we obtain in succession:

$$\log(k_j) = 0.96 + \underset{(0.04)}{0.16} \log(k_t)$$

R = 0.71
N = 20
j = major group 0

$$\log(k_j) = 0.79 + \underset{(0.07)}{0.25} \log(k_t)$$

R = 0.66
N = 19
j = major group 1

$$\log(k_j) = 0.83 + \underset{(0.05)}{0.21} \log(k_t)$$

R = 0.71
N = 19
j = major group 2

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* b = 1.45 with a remarkably small standard deviation (0.06).

The "impact" of the educational system measured by the number of years of schooling is felt much less strongly in these categories, as shown by the low elasticities obtained. Furthermore, the average level of education of these categories seems to be rather poorly defined in the absence of any weighting of the years of schooling.

*

* *

In conclusion, it thus seems clear that the level of education of the different occupational categories is, in many cases, strongly influenced by the educational structure of the total labour force. It would, therefore, appear that this is suggestive for the existence of educational supply effects. In other words, the development and expansion of educational systems seem to play a role of their own in the explanation of the observed educational profiles and levels of occupational categories. In the next chapter, we will attempt to develop the analysis somewhat further by combining these educational "push" factors with the economic and technological "pull" factors.

XIII

LEVELS OF EDUCATION OF THE DIFFERENT OCCUPATIONAL CATEGORIES, TECHNOLOGICAL INDICATORS, OCCUPATIONAL AND/OR EDUCATIONAL STRUCTURE OF THE LABOUR FORCE

1. INTRODUCTION

The object of this analysis is to confirm the existence of significant relationships between the three types of variable so far studied; the relationships between these variables taken in pairs have already been dealt with in Chapters IX, X and XI (levels of education of the different occupational categories as related to economic indicators or the occupational structure), and in Chapter XII (levels of education of the different occupational categories and educational structure of the labour force).

In Chapters IX, X and XI, we tried to estimate the fraction of the variance in Ljk/L which was exclusively due to the economic indicators or the occupational structure, for the time being deliberately ignoring any other causes of variation in Ljk/L. In Chapter XII, we left the economic variables out of account, and tried to show how the educational profile of the different occupations was affected by the "push" from educational systems, whose earlier development (with some exceptions in Eastern European countries) was not made dependent on explicit economic objectives.

Bearing in mind that the independent variables do not account for the entire variance in Ljk/L, an attempt has here been made to estimate the combined influence of the economic indicators and educational structures on the level of education in the different occupational categories. The purpose of this chapter is thus to provide a somewhat more accurate image of the variations in Ljk/L, as these depend both on the needs of the economy and on the earlier development of the educational system. An attempt will also be made to determine, as far as possible, the dominant influence in each case.

As a first step, the economic indicators and the educational structure of the labour force will, therefore, be combined in a multiple regression equation in double-logarithmic form:

$$\log (Ljk/L) = \log a + b \log (Lk/L) + c \log (n),$$

with n representing any one of the economic variables.

The occupational structure of employment will then be substituted for the economic variables, for reasons already mentioned in Chapter XI. We shall then test:

$$\log (Ljk/Lj) = \log a + b \log (Lk/L) + c \log (Lj/L)$$

The reasons for using Ljk/Lj instead of Ljk/L are given in section 3.

2. LEVELS OF EDUCATION OF THE DIFFERENT OCCUPATIONAL CATEGORIES, ECONOMIC VARIABLES AND EDUCATIONAL STRUCTURE OF THE LABOUR FORCE

We need not revert here to the significance of the dependent variables - successively Ljk/Lj and Ljk/L - since this has been dealt with previously. The explanatory variables present no particular problems: n will be sometimes labour productivity (X/L), sometimes investment ($\Sigma I/L$) or the non-monetary indicator (Ie).

The multiple regression equations were tested by the step-wise system, which consists, it will be remembered, first in, selecting the independent variable giving the best correlation with Ljk/L or Ljk/Lj, then introducing into the equation additional explanatory variables only insofar as they can improve the correlation.

In each case, i.e., for each category j associated with a level of education k, two types of equations were tried:

- one with Lk/L, X/L, $\Sigma I/L$ as explanatory variables,
- the other with the same explanatory variables, plus the indicator Ie,

giving four equations in all - two for each dependent variable.

The underlying statistical assumption is that, if two types of explanatory variable (Lk/L and n) are taken into account, this should enable a larger fraction of the variance in Ljk/L or Ljk/Lj to be "explained" than if the variables were taken separately. Accordingly, we showed in Table III-6 only the equations which confirm this assumption. They are moreover the same as those yielding significant coefficients of elasticity, i.e. amounting to more than twice their standard deviation.

It will be seen that the "eight years' schooling or less" level and the "lower" categories in the occupational hierarchy, are not included in Table III-6. While it is easy to explain the absence of D level which, when broken down by occupational categories, failed to yield results, these being only obtained for the total labour force, various interpretations are possible as regards the "sales workers" and "manual workers and craftsmen" categories, for which no significant relationships were previously obtained.

- One possible explanation lies in the existing correlations between the explanatory variables Lk and n. It is, however, hard to see why these variables, which are the same for all occupational categories, should affect the "sales workers" and "manual workers and craftsmen" groups more than the others.

- The often high correlation obtained with $Ljk/L = f(n)$ and $Ljk/L = f(Lk/L)$ separately may prevent any further improvement. A quick glance at Tables III-2 and III-5 does, however, show that some other occupational groups are in the same position.
- In actual fact, these two categories have already stood apart from the others on two occasions: the equations $Lj/L = f(n)$ and $Ljk/L = f(Lj/L)$ give practically no significant results in their cases.* In diagrammatic form, if $\longrightarrow$ symbolizes a significant relationship, and $\dashrightarrow$ the absence of any significant relationship, we obtain for these two groups:

$$\begin{tikzcd}
(Ljk/L) & (Lk/L) \arrow[l] \\
(Lj/L) \arrow[u, dashed] & (n) \arrow[l, dashed] \arrow[u] \arrow[ul]
\end{tikzcd}$$

If then, the absence of any significant relationship between Lj/L and n, in particular, goes along with poor correlations for $Ljk/L = f(Lk/L, n)$, better results might properly be expected if n were replaced by Lj/L. If this were so, Lj/L, not n, would represent the needs of the economy in these two groups, insofar as Lj/L could be linked to other indicators than those considered so far: see section 3 below.

To revert to Table III-6, the step-wise system selected in the first place the variable Lk/L, then one of the economic indicators X/L (^{a}n) or $\Sigma I/L$ (^{b}n), without it being possible to say that one is used more systematically than the other, with better results.

When Ie (^{c}n) is also included among the explanatory variables, it is fairly often chosen, but always after the variable Lk/L: see the relationships indicated under Table III-6.

In the few cases where both equations, with Ljk/L and Ljk/Lj as the respective dependent variables, give significant results, the differences already noted in the quality of the correlation subsist in favour of the Ljk/L equations; it is, however, only fair to point out that the differences are smaller than those noted in previous sections, especially for major groups 0 and 2.

If, furthermore, the correlations obtained with Lk/L and n combined are compared with those obtained with n (Chapter X) and Lk/L (Chapter XII) separately, the following points emerge:

1. The correlations between Ljk/L and n are always inferior to those between Ljk/L and Lk/L. But this is at least partly due to the fact that the observational errors are larger for n, which

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* See Tables III-2 and III-4. A different interpretation must be sought for technicians (0X), who do not appear in Table III-6 either; in this case we seem to come up against a problem of classification which the small number of observations at our disposal does not allow us to overcome.

Table III-6. MULTIPLE REGRESSION EQUATIONS LINKING THE LEVELS OF EDUCATIONAL CATEGORIES (Ljk/L and Ljk/Lj), TO SOME ECONOMIC INDICATORS (n) AND THE EDUCATIONAL STRUCTURE OF TOTAL LABOUR FORCE (Lk/L)

$$\log(Ljk/L) = \log a + b \log(Lk/L) + c \log(n); \quad \log(Ljk/Lj) = \log a + b \log(Lk/L) + c \log(n)$$

OCCUPATIONAL CATEGORIES		DEGREE LEVEL AND ABOVE (A)				COMPLETED SECONDARY SCHOOLING AND ABOVE (B)				MORE THAN EIGHT YEARS OF SCHOOLING (C)			
		R	log a	b(σ b)	c(σ c)	R	log a	b(σ b)	c(σ c)	R	log a	b(σ b)	c(σ c)
		1	2	3	4	5	6	7	8	9	10	11	12
Major Group 0	Ljk/L	^{1}				0.93^{5}	-0.75	0.55(0.11)	^{b}0.23(0.09)	0.96	-0.74	0.50(0.10)	^{b}0.23(0.07)
	Ljk/Lj	0.91	1.98	0.71(0.08)	^{b}-0.26(0.07)	0.91	1.93	0.40(0.05)	^{a}-0.17(0.05)	0.87	1.94	0.29(0.06)	^{a}-0.13(0.05)
Minor Groups 00/01/02/0X	Ljk/L	0.95	-1.62	0.74(0.12)	^{a}0.28(0.14)								
	Ljk/Lj	0.63^{2}	2.85	0.59(0.20)	^{a}-0.49(0.23)								
Major Group 1	Ljk/L	0.90	-1.89	0.82(0.14)	^{b}0.30(0.13)	0.93	-1.97	0.80(0.15)	^{a}0.33(0.16)				
	Ljk/Lj	0.50	-0.64	0.27(0.17)	^{b}0.10(0.16)								
Major Group 2	Ljk/L	0.91^{3}	0.42	1.58(0.17)	^{b}-0.56(0.16)	0.94^{6}	-0.17	1.22(0.14)	^{b}-0.23(0.12)	0.97	-1.[illegible]	0.57(0.12)	^{a}0.38(0.11)
	Ljk/Lj	0.85^{4}	2.68	1.22(0.17)	^{b}-0.86(0.16)	0.69^{7}	2.24	0.75(0.20)	^{b}-0.47(0.17)				

NOTES: "n" indicates the economic variables. Each regression coefficient is preceded by the index "a" for labour productivity, "b" for gross capital formation per worker, and "c" for non-monetary index.

Other significant relationships:

1. 0A $\log(Ljk/L) = -0,64 + \underset{(0,06)}{0,82} \log(Lk/L) + \underset{(0,10)}{0,33} \log(Ie)$ R = 0,98
2. 9A $\log(Ljk/Lj) = 2,60 + \underset{(0,21)}{0,69} \log(Lk/L) - \underset{(0,35)}{0,86} \log(Ie)$ R = 0,67
3. 2A $\log(Ljk/L) = 0,48 + \underset{(0,18)}{1,81} \log(Lk/L) - \underset{(0,27)}{1,24} \log(Ie)$ R = 0,93
4. 2A $\log(Ljk/Lj) = 2,69 + \underset{(0,16)}{1,54} \log(Lk/L) - \underset{(0,25)}{1,84} \log(Ie)$ R = 0,91
5. 0B $\log(Ljk/L) = -0,72 + \underset{(0,10)}{0,48} \log(Lk/L) + \underset{(0,14)}{0,51} \log(Ie)$ R = 0,95
6. 2B $\log(Ljk/L) = 0,31 + \underset{(0,14)}{1,24} \log(Lk/L) - \underset{(0,20)}{0,41} \log(Ie)$ R = 0,94
7. 2B $\log(Ljk/Lj) = 2,10 + \underset{(0,18)}{0,85} \log(Lk/L) - \underset{(0,25)}{0,95} \log(Ie)$ R = 0,77

causes the correlation coefficients between Ljk/L and n to be under-estimated. Conversely, any errors of observation for Lk/L recur, at least partly, in Ljk/L; their influence is thus negligible. The same argument can be advanced in the case of Ljk/Lj.

2. The correlations obtained for Ljk/L = f (Lk/L, n) are always slightly better than those obtained for Lk/L alone, or n alone, which gives some support to our initial assumption, namely, that the level of education of the different occupational groups is better "explained" by the combined influence of the economic indicators and the educational structure of the labour force. The improvements are often extremely small, especially when the Ljk/L = f (Lk/L) correlations are already very good. When Ljk/Lj is the dependent variable, on the other hand, the improvements are usually substantial; this is quite understandable, since the correlations are only mediocre for Lk/L alone, and *a fortiori* n alone.

Table III-6 includes all the significant regression coefficients*, which are analysed below:

i) Equations in the form: Ljk/Lj = f (Lk/L, n)

In these equations, the elasticity for Lk/L is always positive, whereas for the economic variables (n) it is always negative. Furthermore, it is generally higher, in absolute figures, in the first case than in the second, with some exceptions which will be set forth below.

When log (Lk/L) and log (n) both vary by 1%, log (Ljk/Lj) always increases by a percentage equal to the difference in their elasticities. In other words, the "push" of the educational system acts as the driving force, with the "needs" of the economy acting in some sort of a brake.

Thus, for major group 0, at university-degree level, we obtain:

$$\log (Ljk/Lj) = 1.98 + \underset{(0.08)}{0.71} \log (Lk/L) \underset{(0.07)}{-0.26} \log (n) \qquad R = 0.91$$

log (Ljk/Lj) here rises by 0.45% for each variation of 1% in the explanatory variables. If the "needs" of the economy are maintained constant, log (Ljk/Lj) will rise faster (by 0.71%) with each 1% increment in the supply from the educational system. If, on the other hand, there is no change in the latter (Lk/L constant), Ljk/Lj will decline with every increase in productivity, for example. This is not unduly surprising; when X/L rises, Lj/L will also tend to rise; if, at the same time, Ljk/L tends to remain constant (being closely correlated with Lk/L, which is itself constant), there are two good reasons why the Ljk/Lj ratio should diminish.

There are two important exceptions to these interpretations of the results obtained:

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* As well as some which are not significant (i.e. less than twice their standard deviations) for reasons explained above.

a) The first relates to group 00/01/02/0X; even in Table III-6, where n represented productivity, it cannot safely be concluded that an elasticity for Lk/L will be higher than for X/L, owing to the standard deviations. The inclination is in fact to assume the contrary, if we consider:

$$\log (Ljk/Lj) = 2.60 + \underset{(0.21)}{0.69} \log (Lk/L) - \underset{(0.35)}{0.86} \log (Ie) \qquad R = 0.67$$

j representing 00/01/02/0X and k "university-degree level or above". When the explanatory variables vary, Ljk/Lj should therefore remain constant or even decline. This can no doubt be explained by the fact that the numbers in this occupational group holding a university degree (Ljk) rise at the same rate as the total numbers (Lj), or even more slowly, having regard to the greater relative importance of middle-level technical workers as development proceeds.

b) For clerical workers at "university-degree level", the situation is rather the same; we have:

$$\log (Ljk/Lj) = 2.69 + \underset{(0.16)}{1.54} \log (Lk/L) - \underset{(0.25)}{1.84} \log (Ie) \qquad R = 0.91$$

Here again, Ljk/Lj would diminish, or at most remain constant, and countries at such different stages of development as, say, Canada and the Philippines would have the same proportion of clerical workers with university degrees. While this may not be an unacceptable proposition, having regard to the intellectual under-employment prevailing in many developing countries, it does not hold good when the non-monetary indicator is replaced by "capital"; this gives:

$$\log (Ljk/Lj) = 2.68 + \underset{(0.17)}{1.22} \log (Lk/L) - \underset{(0.16)}{0.86} \log (\Sigma I/L) \qquad R = 0.85$$

according to which log (Ljk/Lj) would increase by nearly 0.40% whenever the explanatory variables increased by 1%.

A similar calculation might be made for clerical workers of "completed secondary level or above", which illustrates the importance of $\Sigma I/L$ for the educational profile of this occupational group.

To sum up, the Ljk/Lj ratio is subject, in the equations considered, to opposite influences with a variable resultant; either the "push" of supply gets the better of the strict "needs" of the economy, and Ljk/Lj rises; or else, the two influences roughly cancel out each other, and Ljk/Lj remains stable. In certain cases, the ratio may even decline, although the lack of precision in the elasticity coefficients should incline towards caution.

Some thought should, however, be given to the significance of this negative influence of "needs". It is entirely due to the fact that the influence seems to be mainly exerted through Lj, which is the denominator of the Ljk/Lj ratio ? Or are there other reasons ? The following paragraph may throw some light on the matter.

ii) Equations in the form: $Ljk/L = f(Lk/L, n)$

The elasticities of Lk/L and n are both positive, the first being always distinctly higher than the second for all occupational categories at all levels of education. There are a few rare exceptions to this general rule which are dealt with below.

In other words, the effects of the "push" exerted by the educational system are, in most cases, added to the "needs" of the economy to determine Ljk/L, the former being in some way distinctly more important than the latter. Judging by the partial elasticities, about 70% of the variation in Ljk/L may even be ascribed to variations in the "supply" of the educational system.* What is more certain** is that this proportion seems to remain the same, whatever occupational group or level of education is considered.

A first acceptable finding would certainly be that the supply from the educational system is a more important factor than the strictly economic needs in determining the levels of education of the different educational categories. It is still difficult to explain, however, why this division of influence remains the same in every case; the influence of supply (Lk/L) might thus be expected to be greater at the lower levels of education, which often account for the majority of the labour force.

Meanwhile, the exceptions mentioned will, perhaps, throw some light on the matter:

For major group 0, at "completed secondary level or above", it was also found with the non-monetary indicator that:

$$\log(Ljk/L) = -0.72 + \underset{(0.10)}{0.48} \log(Lk/L) + \underset{(0.14)}{0.51} \log(Ie) \qquad R = 0.95$$

In this equation, the "push" from the educational system and the "needs" of the economy have a roughly equal influence on the determination of Ljk/L.

For major group 2, at "university-degree level" and "completed secondary level or above", the exception is of another kind: while the elasticity for n is still, in absolute value, well below that for Lk/L, this time it is negative. At "university-degree level" we thus get:

$$\log(Ljk/L) = 0.48 + \underset{(0.18)}{1.81} \log(Lk/L) - \underset{(0.17)}{1.24} \log(Ie) \qquad R = 0.93$$

i.e., the situation is exactly the same as for the Ljk/Lj equations. It is indeed quite conceivable that the proportion of the total labour force represented by clerical workers who are university graduates should mainly depend on the available number of graduates. The negative elasticity for Ie may be interpreted as follows: in the early stages of development, some university graduates take office jobs where their capacities are not used to the utmost for lack of other work more suitable to their education. As development proceeds, Lk/L remaining constant, the graduates leave these office jobs for newly created professional posts; Ljk/L will therefore tend to diminish.

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* This is merely a rough approximation intended as a basis for our argument, since it takes no account of the interaction between the explanatory variables.

** As the interaction alluded to in footnote* is roughly the same in all the equations.

iii) Equations in the form: $k_j = f(k_t, n)$

Significant results were obtained only for clerical workers:

$$\log(k_j) = 0.98 + \underset{(0.07)}{0.33}\log(k_t) - \underset{(0.07)}{0.16}\log(Ie) \qquad R = 0.79$$

and for sales workers:

$$\log(k_j) = 0.33 + \underset{(0.08)}{1.15}\log(k_t) - \underset{(0.05)}{0.13}\log(\Sigma I/L) \qquad R = 0.97$$

Here the number of years of education embodied in the active population might be expected to be the prevailing influence; in the case of sales workers, it even appears that, k_t being kept constant, there is some substitution between human "capital" (k_j) and physical "capital" ($\Sigma I/L$): as the latter increases the former decreases, and vice versa.

iv) Other significant relationships

In certain cases, the step-wise programme selected not one but two technological indicators, in addition to Lk/L.

a) Table III-6 gives for managerial workers at "university-degree level" at Ljk/Lj equation whose regression coefficients are lacking in significance. They acquire meaning if an additional economic variable is introduced into the equation; thus we obtain:

$$\log(Ljk/Lj) = 1.62 + \underset{(0.16)}{0.40}\log(Lk/L) + \underset{(0.35)}{0.79}\log(\Sigma I/L) - \underset{(0.46)}{1.01}\log(X/L) \quad R = 0.64$$

b) At the "more than eight years' schooling" level, some of the correlations in Table III-6 can be further improved with a third explanatory variable. This is the case for "professional workers", where we have:

$$\log(Ljk/L) = -0.41 + \underset{(0.10)}{0.58}\log(Lk/L) + \underset{(0.14)}{0.47}\log(\Sigma I/L) - \underset{(0.19)}{0.37}\log(X/L) \quad R = 0.98$$

and for "clerical workers", with:

$$\log(Ljk/L) = -1.55 + \underset{(0.11)}{0.56}\log(Lk/L) + \underset{(0.21)}{0.73}\log(X/L) - \underset{(0.15)}{0.29}\log(\Sigma I/L) \quad R = 0.98$$

The small gain in quality of correlation in these relationships is, however, offset by the loss in precision of the coefficients of elasticity. This was in fact foreseeable, since it was shown in Chapter VI that the economic indicators could not be regarded as complementary in determining levels of education for the different occupational categories.

The relationships will thus be of little practical utility, and are mentioned here only for the record.

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Throughout the preceding sections, the levels of education of the different occupational categories were correlated with the educational structure of the labour force (Lk/L) and the economic indicators (n). In the same way as we replaced these indicators by the occupational structure of employment (Lj/L) in Chapter X, we shall here carry out a similar substitution for the same reasons, namely:

- Lj/L can constitute a valid substitute for n in every case where there is close correlation between them. These cases are set forth in detail in Part Two of this study, and in Chapter X of Part Three. *
- In cases where there is no significant link between Lj/L and n**, the above analysis and the accompanying Table III-6 have emphasized the absence of meaningful results in the equations with Lk/L and n as explanatory variables, a further reason for substituting Lj/L for n.
- A third purely statistical reason is that, since observational errors for n are not the same as for Ljk/L and Lk/L, considerable distortions may ensue in estimating the influence attributed to economic "needs". If such a variable as Lj/L is substituted for n this may help to eliminate any uncertainty on this point.

3. EDUCATIONAL PROFILE OF THE DIFFERENT OCCUPATIONAL CATEGORIES, OCCUPATIONAL AND EDUCATIONAL STRUCTURE OF THE LABOUR FORCE

The chief reasons why we shall test here only the educational profile of the different occupational categories (Ljk/Lj), leaving aside the levels of education (Ljk/L), are as follows:

- As we saw in Chapter XII, the available supply of qualified manpower at all levels was, in certain cases, able to influence the educational profile of the different occupational categories.*** To go one step further, the proportion of people with a given level of education in a given occupational group can in fact be expected to depend on the total work-force in that group and on the total number of people with this level of education available in the labour force.

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* Which in fact merely confirms the analysis in Part Two, made with a much larger sample of countries.

** "Sales workers" and "manual workers and craftsmen" categories, and possibly "technicians".

*** See the results of the equations in the form Ljk/Lj = f (Lk/L) in Table III-5.

- Secondly, apart from an undoubted risk of artificial correlations, equations in the form Ljk/L = f (Lk/L, Lj/L) contain a notable constraint arising out of the very definition of the variables; thus Ljk/L will always be lower than Lk/L and Lj/L, that is to say, lower than the smaller of the two; this may automatically introduce links between these three variables which have nothing to do with links of statistical dependence. The ratio Ljk/Lj, however, is less dependent on Lk/L and Lj/L: by definition, it may be greater than, equal to or smaller than these two variables whether taken together or separately.
- Lastly, there is no need to show Ljk/L equations as well as Ljk/Lj equations. As pointed out, owing to the tautological relationship Ljk/Lj = (Ljk/L).(L/Lj), the parameters of these two equations are linked by simple mathematical relationships.* The multiple correlation coefficients differ slightly: they are generally higher for Ljk/L than for Ljk/Lj.

The results of the equations in the form,

$$\log (Ljk/Lj) = \log a + b \log (Lk/L) + c \log (Lj/L)$$

are given in Table III-7.

The correlations are fairly good (R > 0.70) in major groups 0, 2, 3 and 7/8, for scientific and technical manpower (00/01/02/0X) at university-graduate level, and for technicians (0X) at "completed secondary level or above". They are rather poor for major group 1. If these correlations are compared with those in Table III-5: Ljk/Lj = f (Lk/L), there is found to be a considerable improvement in most cases.

Whereas elasticities for Lk/L are always positive, for Lj/L they are negative in every case at three levels of education: university, secondary, and more than eight years' schooling. Here again, the available supply of graduates (Lk/L) affects the educational profile of the occupational categories in a positive direction, while variations in the occupational structure** tend to reduce Ljk/Lj, Lj being the denominator.

If the elasticities are compared in absolute figures, the situation is very different from that described previously with Lk/L and n as explanatory variables. Although the elasticity for Lk/L is never lower than that for Lj/L, the differences are much smaller, and in many cases practically nil.

At the "eight years' schooling or less" level, the elasticities for Lj/L are also positive. The Ljk/Lj ratio is here very sensitive to the available supply of manpower at this level (high elasticity for Lk/L), an influence further reinforced by increments of Lj/L, but only for categories at the bottom of the occupational ladder***; it is thus

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* See footnote * on page 144. It will be remembered that these relationships operate so long as (a) double-logarithmic equation is involved, (b) Lj/L is an explanatory variable. Whenever there are two explanatory variables, the second is affected by the same elasticity in both equations. The standard deviations are the same in both equations.

** Themselves linked to the development indicators in some but not all cases, as we have seen.

*** The elasticities for Lj/L in major groups 0 and 1 are not significant.

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Table III-7. MULTIPLE REGRESSION EQUATIONS LINKING THE EDUCATIONAL PROFILE OF OCCUPATIONAL CATEGORIES (Ljk/Lj) TO THE OCCUPATIONAL AND EDUCATIONAL STRUCTURES OF THE LABOUR FORCE

$$\log (L_{jk}/L_j) = \log a + b \log (L_k/L) + c \log (L_j/L)$$

OCCUPATIONAL CATEGORIES	DEGREE LEVEL AND ABOVE (A)				COMPLETED SECONDARY SCHOOLING AND ABOVE (B)				MORE THAN EIGHT YEARS OF SCHOOLING (C)				EIGHT YEARS OF SCHOOLING AND LESS (D)			
	R	log a	b(σ b)	c(σ c)	R	log a	b(σ b)	c(σ c)	R	log a	b(σ b)	c(σ c)	R	log a	b(σ b)	c(σ c)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Major Group 0 ...	0,95	1,64	0,86(0,06)	-0,70(0,10)	0,88	1,58	0,36(0,06)	-0,19(0,09)	0,77	1,69	0,28(0,08)	-0,21(0,11)	0,59	-3,74	2,47(1,09)	0,42(0,55)
Minor Groups 00/01/02/0X	0,86	1,28	0,73(0,12)	-0,61(0,10)	0,63	1,48	0,34(0,13)	-0,22(0,17)								
Minor Group 0X ..	0,61	0,09	0,85(0,41)	-0,84(0,48)	0,79	1,32	0,40(0,13)	-0,13(0,16)								
Major Group 1 ...	0,65	1,00	0,81(0,20)	-0,74(0,23)	0,62	1,19	0,54(0,16)	-0,48(0,17)	0,41	1,42	0,31(0,25)	-0,16(0,22)	0,47	-1,08	1,38(0,69)	0,28(0,21)
Major Group 2 ...	0,71	1,02	1,33(0,28)	-1,37(0,39)	0,82	1,21	1,27(0,21)	-1,21(0,26)	0,76	1,57	0,48(0,11)	-0,49(0,13)	0,80	-2,96	2,17(0,45)	0,54(0,18)
Major Group 3 ...	0,81	0,06	1,04(0,16)	-0,58(0,23)	0,86	0,45	1,23(0,18)	-0,83(0,22)	0,87	0,81	0,96(0,15)	-0,77(0,17)	0,88	-1,02	1,34(0,21)	0,42(0,08)
Major Groups 7/8 .					0,90	0,64	2,01(0,24)	-1,58(0,28)	0,91	0,78	1,50(0,18)	-1,15(0,20)	0,87	-0,52	0,98(0,20)	0,45(0,07)

understandable that, in these categories, and these alone, rapid growth of the work-force should be achieved by an intake of personnel with little or no education.

The precision of elasticities is extremely variable, and generally less for Lj/L than for Lk/L, so that they may sometimes be deprived of all significance. Thus the educational profile of major group 0 is statistically determined only at two levels of education k (university-degree and completed secondary level or above). It should also be noted that this imprecision sometimes coincides with relatively good correlations.

We shall now say a word about the trend of Ljk/Lj for each occupational group, restricting ourselves to the most significant elasticities.

For major group 0 at university level, the "push" effect of the educational system is almost nullified by the increased importance of this group in the total labour force (Lj/L); the resultant is a slight upward trend for Ljk/Lj (the difference in elasticities is only 0.16). At "completed secondary level or above", on the other hand, the influence of Lk/L is twice as strong as that produced by the increase of Lj/L. The resultant for Ljk/Lj is however very little higher than at university level: the difference in elasticities is 0.19. Our conclusion must be that the educational profile of this group is gradually improving (through a decrease in the numbers with "eight years' schooling or less"), but that the ratio between work forces at the various levels of education remains constant. *

The educational profile of scientific and technical manpower can be determined only at "university-degree" level. The available supply at this level grows slightly faster than the total numbers in this category, which means that Ljk/Lj should also rise slightly at this level. This result, which does not altogether agree with those previously obtained**, highlights, through introducing Lk/L, the "push" effect of the educational system as regards science degrees.

The educational profile of "technicians" cannot be determined by this method. The difficulties of defining this group, together with the diversity of relevant levels or types of education***, indicate each country's own peculiarities in this field.

The results for major group 1 are significant at "university-degree level" and "completed secondary level or above", and it may even be claimed that the effect of the available supply of qualified manpower at both levels is practically offset by the rapid increase in the total work force in the group. In other words, Ljk/Lj will remain almost constant, which corroborates our previous conclusions****, namely, that the development of the education system at these levels, and the flow of qualified manpower into this occupational group, will be offset by a rise mainly due to the mass of service workers running craft businesses with only one or two employees.

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* Since Ljk/Lj rises at roughly the same rate. This would also hold good for the "more than eight years' schooling" level if precision of the elasticities were better. It may be noted in passing that this conclusion was previously reached in discussing the equations of the Ljk/L = f (Lj/L) type; see Chapter XI and Table III-4.

** Chapter XI and Table III-4.

*** In some countries, technical education may be included with university education; in others, it may not go beyong secondary level; in others again, there is no formal technical education, properly speaking.

**** Chapter XI.

The educational profile of major group 2 remains almost constant at all three "university", "secondary" and "more than eight years' schooling" levels; the respective influences of Lk/L and Lj/L in fact cancel out each other. This contradicts our previous conclusions*, which pointed to slight increases for Ljk/Lj at both university and secondary level. In other words, the explicit introduction of the "push" effect exerted by the education system as an explanatory variable of the educational profile causes the relative influence of Lj/L to diminish; new entrants into the group would thus tend to be distributed among the various levels of education as determined by the existing educational profile.

In major group 3, Ljk/Lj tends to rise at roughly the same rate at "university-degree" and "secondary" level (the difference between the elasticities is 0.40 - 0.45), and twice as slowly at the "more than eight years' schooling" level (b - c = 0.20). At all three level, the supply from the educational system is thus of greater importance as an explanatory variable than Lj/L.** Hence the more the latter develops the more the educational profile of this group will have a chance to improve.

The same remarks could be made as regards major group 7/8: Ljk/Lj rises at "completed secondary level or above" and "more than eight years' schooling" levels, because of the very high elasticities for Lk/L. The high sensitivity of the educational profile to the available supply of qualified manpower occurs, as it normally should, in the "lower" groups of the occupational hierarchy, in the sense that these are the last to be served where the question of education is concerned.

4. EDUCATIONAL AND OCCUPATIONAL STRUCTURE OF THE TOTAL LABOUR FORCE

After having related the educational profile of the different occupational categories to the occupational and educational structure of the total labour force, it is important to find out whether these two variables are sufficiently independent of each other. If not, it will be useful to determine the relationship between them. As we saw in a previous section, their elasticities are roughly equal and of opposite sign; some idea must therefore be gained of their relative rates of variation in order to determine the trend of Ljk/Lj. Thus, only if these rates are equal can equations of the form Ljk/Lj = f (Lk/L, Lj/L) be sufficient in themselves to reveal the resulting changes in Ljk/Lj.

We chose to test the relationship:

$$\log (Lk/L) = \log a + b \log (Lj/L)$$

Here the sequence is of little importance; the interest of the equation lies entirely in showing the elasticity of Lk/L in relation to Lj/L, but the inverse elasticity would have suited our purpose just as well. Whenever this elasticity is close to 1, the equations in section 3 will be self-sufficient; whenever the elasticity diverges from 1, the difference will have to be taken into account for the interpretation of the equations.

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* Chapter XI.

** Which explains why the present conclusions are different from those in Chapter XI, where Lk/L was not taken into consideration.

The parameters of this relationship are shown in Table III-8.

At the three levels of education A, B and C, the elasticities are substantially greater than 1 for major group 0, appreciably equal to 1 for major group 2, between 0.80 and 1.00 for major group 1, and under 0.80 for the other occupational categories.

Thus, for clerical workers, the conclusions in the previous section - namely, equal influence of opposite sign for the available supply of qualified manpower and the occupational structure - will hold good.

For categories 0X and 3, the correlations are poor and the elasticities lack significance; it can, therefore, be assumed that Lk/L and Lj/L are relatively independent of each other. In groups 7/8 and, to a lesser extent, group 1, the available supply of qualified manpower changes more slowly than their proportion in the total labour force; this should be borne in mind when measuring their influence on the educational profile of the different occupational categories. Conversely, for "professional workers", the predominant influence of Lk/L on Ljk/Lj may be further strengthened by the fact that Lk/L changes faster than Lj/L ($1.15 < b < 1.30$).

5. MEAN LEVEL OF EDUCATION OF THE DIFFERENT OCCUPATIONAL CATEGORIES AND OF THE TOTAL LABOUR FORCE AND OCCUPATIONAL STRUCTURE

The results obtained by linking the mean years of schooling for the different occupational categories to those for the total labour force and to the occupational structure of employment, i.e.,

$$\log (k_j) = \log a + b \log (k_t) + c \log (Lj/L)$$

confirm the previous conclusions, namely that:

- the influence of the mean level of education of the total labour force increases as one moves down the occupational ladder;
- the influence of the occupational structure has the opposite effect from k_t, and is particularly marked for the manual, sales and clerical worker categories.

The following equations illustrate these propositions:

$$\log (k_j) = 0.61 + \underset{(0.06)}{1.03} \log (k_t) - \underset{(0.12)}{0.40} \log (Lj/L)$$

R = 0.98
j = all manual worker categories, except farmers

Table III-8. SIMPLE REGRESSION EQUATIONS LINKING THE EDUCATIONAL STRUCTURE (Lk/L) TO THE OCCUPATIONAL STRUCTURE OF THE LABOUR FORCE (Lj/L)

$$\log (Lk/L) = \log a + b \log (Lj/L)$$

OCCUPATIONAL CATEGORIES	DEGREE LEVEL AND ABOVE (A)				COMPLETED SECONDARY SCHOOLING AND ABOVE (B)				MORE THAN EIGHT YEARS OF SCHOOLING (C)				EIGHT YEARS OF SCHOOLING AND LESS (D)			
	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Major Group 0	25	0.72*	-0.61	1.16(0.23)	21	0.76*	0.01	1.28(0.25)	17	0.88*	0.32	1.28(0.18)	17	-0.76*	2.13	-0.38(0.08)
Minor Groups 00/01/02/0X	19	0.70*	0.23	0.61(0.15)	14	0.59	0.90	0.77(0.30)								
Minor Group 0X	12	0.43	0.32	0.51(0.33)	9	0.46	1.00	0.57(0.41)								
Major Group 1	25	0.81*	0.00	0.95(0.14)	21	0.81*	0.71	0.83(0.14)	17	0.93*	0.96	0.83(0.09)	17	-0.76*	1.94	-0.23(0.05)
Major Group 2	25	0.78*	-0.62	1.09(0.18)	21	0.81*	0.14	1.03(0.17)	17	0.85*	0.44	1.02(0.16)	17	-0.70*	2.08	-0.29(0.08)
Major Group 3	25	0.25	-0.12	0.35(0.29)	21	0.27	0.64	0.33(0.27)	17	0.48	0.74	0.54(0.26)	17	-0.35	1.98	-0.14(0.09)
Major Groups 7/8					21	0.58*	0.00	0.70(0.22)	17	0.64*	0.31	0.68(0.21)	17	-0.47	2.09	-0.17(0.08)

$$\log(k_j) = 0.52 + \underset{(0.05)}{1.01} \log(k_t) - \underset{(0.11)}{0.54} \log(Lj/L) \qquad R = 0.98 \quad j = \text{sales workers}$$

$$\log(k_j) = 0.86 + \underset{(0.08)}{0.35} \log(k_t) - \underset{(0.08)}{0.18} \log(Lj/L) \qquad R = 0.80 \quad j = \text{clerical workers}$$

For major groups 0 and 1, the elasticities for Lj/L do not significantly depart from 0.

Lastly, the relationship between the explanatory variables was tested by the following equation:

$$\log(k_t) = \log a + b \log(Lj/L)$$

For sales workers, there is almost perfect independence between these two variables. The only elasticity higher than 1 is that for all manual worker categories (except farmers), for which we find:

$$\log(k_t) = -1.29 + \underset{(0.35)}{1.25} \log(Lj/L) \qquad R = 0.64 \quad N = 20$$

For clerical workers, on the other hand, the mean level of education of the labour force seems to grow more slowly than Lj/L; we find:

$$\log(k_t) = 0.10 + \underset{(0.14)}{0.80} \log(Lj/L) \qquad R = 0.81 \quad N = 20$$

This should be taken into account in determining variations of k_j.

XIV

CONCLUSIONS

Our study of the occupational categories/levels of education matrices has thus developed in the following three directions.

i) First, we tried to find out whether there was any econometric link between levels of education in the different occupational groups and the level of economic development as shown by certain indicators; this analysis can be symbolized by the function:

$$Ljk/L = f(n) \qquad (1)$$

We noted that this link existed for certain j's associated with certain k's: we called them preferential levels of education. The fact remains that, in most cases, the economic indicators account for only a fraction of the variance in Ljk/L. We were thus obliged to look for other explanatory variables.

As the analysis in Part Two seems to justify the conclusion that the occupational structure (Lj/L) of the labour force can largely be "explained" by economic variables, it can legitimately be claimed that the structure, determined in a previous stage, might be regarded as a known quantity for our analysis, one furthermore fairly representative of the level of economic development. Replacing n by Lj/L in the equation (1), we thus obtained and tested the function:

$$Ljk/L = f(Lj/L) \qquad (2)$$

This equation, which gave us a fairly clear idea of the trend of Ljk/Lj, is however subject to some important exceptions, in particular for the occupational groups where the relationship $Lj/L = f(n)$ has not been verified.

ii) In Chapter XII, we deliberately left out the economic indicators and tried to ascertain the impact of the educational system's earlier development on the level of education in the different occupational categories. The result of this earlier development of the educational system is found in the educational structure of the total labour force. There is thus every chance that, in each country, the educational profile of the different occupational groups will reflect the relative abundance of the supply of qualified manpower at all levels in the population. If it is admitted that the rates of activity of such manpower in all countries increasingly coincide the higher we move up the educational ladder, the function:

$$Ljk/L = f\,(Lk/L) \tag{3}$$

can be said to reflect much of the educational system's earlier development and the "distortions" it has caused in the educational profile of certain occupational categories. Accordingly, we also called these equations "distribution equations", as they suggest the existence of a model for the distribution of graduates among the different categories, that is for the occupational choice of graduates, which is common to all countries.

The correlations, which are in many cases excellent, confirm the value of the educational structure of the labour force as an explanatory variable for the levels of education of the different occupational categories.

iii) In a third stage, we compared the analyses described in paragraphs i) and ii): here, then, the level of education should depend both on the level of economic development and the educational structure of the (active) population.

We, therefore, tested the equation:

$$Ljk/L = f\,(Lk/L,\ n) \tag{4}$$

Next n was replaced by Lj/L, for the same reasons as in Chapter XI, this gave the equation:

$$Ljk/Lj = f\,(Lk/L,\ Lj/L) \tag{5}$$

where the educational profile of the different occupational categories depends on both the educational and the occupational structure of the total labour force.

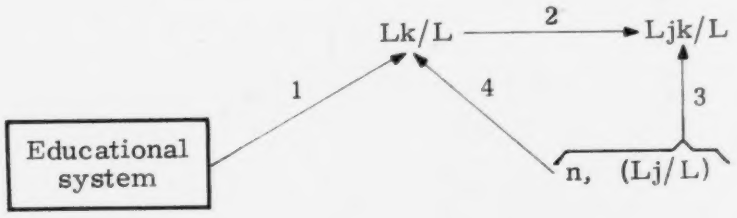
Having regard to the results of equations (4) and (5), one is strongly inclined to conclude that the educational supply effects rather than the "needs" of the economy are the sharply dominating influence in the determination of levels of education (or educational profiles) for the different occupational categories. The reasons for this differ according to the equations considered, leaving all special cases out of account:

- in equation (4), the elasticity for Lk/L is never less than that for Lj/L; it is also invariably more precise;
- in equation (5), the influence of the economic variables is always negative; we said that it acted as some sort of "brake" on the "push" effect from the educational system. This is because Lj is the denominator in the Ljk/Lj ratio, which points again to the difficulties of interpreting variations in this ratio.

As we know, however, interdependence between Lk/L and n or Lj/L is far from being achieved in either type of equation, so that part of the influence of the "needs" of the economy (n or Lj/L) is, in fact, contained in the educational structure of the labour force (Lk/L), and/or vice versa.

In other words, we come back to the fundamental problem of circularity, which may be summarized as follows:

- past and present flows of graduates leaving the educational system to enter the labour market determines Lk/L (arrow 1);
- the available supply of graduates at all levels in the labour force strongly influences the determination of Ljk/L (arrow 2);
- but Ljk/L also depends, although to a lesser extent, on the level of economic development (arrow 3);
- we have clearly explained on two separate occasions the latter's influence on the educational structure of the labour force (arrow 4).



Part Four

ANALYSIS OF RELATIONSHIPS BETWEEN LEVELS OF EDUCATION IN CERTAIN ECONOMIC SECTORS, GENERAL ECONOMIC INDICATORS AND THE EDUCATIONAL STRUCTURE OF THE LABOUR FORCE

Having analysed the occupational structure of the labour force for the economy as a whole and by sectors of economic activity (Part Two), then the educational levels in the different occupational categories (Part Three), we shall now try to "explain" the educational structure of the labour force in the different economic sectors through the use of suitably chosen variables.

This time we shall omit any disaggregation by occupational categories*, and concentrate on economic sectors/levels of education matrices, which may be symbolized as follows:

Country X

LEVEL OF EDUCATION / ECONOMIC SECTORS	A	B...	k...	TOTAL
1	L_{1A}	L_{1B}...	L_{1k}...	L_i
2	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
i	LiA	LiB...	Lik...	Li
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
Total	L_A	L_B...	Lk	L

This is, therefore, a more detailed attempt to link the educational structure of the labour force directly to economic variables without passing through the occupational structure.

Our investigation will be limited to four out of the eight main economic sectors, namely, manufacturing, commerce, transport and services. The agriculture and construction sectors have been excluded, since in most countries the relevant manpower is largely under-educated compared with the other sectors; at high levels of education, the Lik/Li and, a fortiori, the Lik/L percentages are very low and therefore of little significance. In the mining and electricity sectors, the main body of manpower employed (a) is very small in proportion to the total labour force, and (b) varies widely depending on available natural resources, above all in mining.

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* See Part Three.

As regards the measurement of the educational inputs, the same cumulative levels have been adopted as in the previous part, i.e. university degree level or above (A), completed secondary level or above (B), more than eight years' schooling (C), eight years' schooling or less (D). The "mean years of schooling" by sectors have not been calculated for lack of data.

All the preparatory statistical work is explained at length in Annex A; numerical values of observations will be found in Annex H.

The statistical approach will again consist in simple and multiple regression analysis as well as the stepwise system.

The analysis may be divided into three main stages:

1. In a first stage, an attempt will be made to test the link between the level of education of the labour force in each sector and economic indicators specific to that sector. The purpose will thus be to provide an answer to the following basic assumption: is there a correlation between the level of education in a given sector and the level of development in that sector ? And if so, how far does the level of education improve as development proceeds ? The "level of development" will successively be represented by technological and economic variables, and by the sectoral structure of employment, which is itself, as we shall see, largely a function of economic variables.

2. In a second stage, levels of education in the different economic sectors will be correlated with the educational structure of the labour force as a whole. It can legitimately be assumed that these levels are at least partly determined by the available supply of qualified manpower at all levels in the labour force.

3. The third stage will combine the analyses referred to in 1 and 2; the level of education in the different economic sectors will then depend both on the technological variables and the educational structure of the labour force. Here we shall try to determine which of these two types of variables best "explains" the level of education in the different sectors.

XV

LEVELS OF EDUCATION IN THE DIFFERENT ECONOMIC SECTORS, TECHNOLOGICAL INDICATORS AND SECTORAL STRUCTURE OF EMPLOYMENT

1. INTRODUCTION AND BASIC ASSUMPTIONS

i) Levels of education in the different economic sectors and technological indicators

In Part Three, Chapter X, an attempt was made to bring out the statistical link between the educational structure of the total labour force and certain general economic indicators. Our aim now will be to carry the analysis down to the level of a few main economic sectors. More sharply defined statistical relationships may be expected as the homogeneity of the sectors considered increases.

The levels of education in the different economic sectors will be measured by using two different ratios, following a procedure similar to that applied in Part Three for occupational categories. We shall consider in turn:

> Lik/Li, which is the proportion of people in an economic sector i with a level of education k;
>
> Lik/L, which is the number of people in a sector i with a level of education k related to the total labour force.

The explanatory variables used to measure the level of development in a given sector as satisfactorily as possible are obviously specific to each sector. For the reasons already expounded with reference to the overall economy*, the sectoral labour productivity, measured by value added divided by employment in the sector concerned, has been adopted for manufacturing, commerce and transport. GDP *per capita* was adopted for services, since value added in this sector is practically equivalent to the aggregate wages distributed.

Furthermore, whenever possible, non-monetary variables were adopted to mitigate certain known drawbacks in international comparisons of productivity. For services, Niewiaroski's "social" indicator** was adopted (Is); for transport, the number of commercial vehicles per unit of the labour force; and for manufacturing, Niewiaroski's "economic" indicator and the total consumption of energy per head, in turn.

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* See Part Two, Chapter IV.

** See the details of the construction of this indicator in Part Two, page 48.

The levels of education by sectors were correlated with (a) each of the economic variables in succession, using simple regression equations, (b) the same variables taken in pairs, using multiple regression equations. The equations are:

$$\log (Lik/L) = \log a + b \log (Xi/Li)$$

$$\log (Lik/L) = \log a + b \log n, \text{ n being a non-monetary variable}$$

$$\log (Lik/L) = \log a + b \log (Xi/Li) + c \log n.$$

The same equations were tested with Lik/Li as a dependent variable. Here again the double-logarithmic form was chosen, mainly for convenience of use, since, by definition, the regression coefficients of these equations are constant and equivalent to the coefficients of elasticity. The many graphs plotted and tests with other types of equations did not seriously challenge this choice.

ii) Levels of education in the different economic sectors and sectoral structure of employment

Commonsense suggests the likelihood of a relationship between the number of people in a given sector with a given level of education and total employment in the sector. Furthermore, certain studies emphasize the links between sectoral employment and certain sectoral variables of the same type as those referred to in the previous paragraph, while fairly close statistical relationships between production and productivity have already been brought out in certain countries, thus pointing to similar relationships with employment, since this is obtained by dividing one by the other. *

The sectoral structure of employment can, therefore, be regarded as another approximation of the level of development attained in each sector**, which suggests linking the level of education in each sector with the numbers employed as a proportion of total employment, using the relationship:

$$\log (Lik/L) = \log a + b \log (Li/L)$$

Multiple and step-wise regression equations were also tested for Li/L and sectoral productivity on the one hand, giving:

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* Studies dealing with "productivity" in one way or another have proliferated during the last few years. The most exhaustive is certainly John Kendrick's, Productivity Trends in the United States, NBER, New York, 1961. Among others outside the United States may be mentioned: The British Economy in 1975, by W. Beckerman and Associates, NIESR, Cambridge University Press, 1965; "Evolution de la productivité en France depuis 1941 et prévisions pour 1970", in Notes et Etudes documentaires No. 3375, la Documentation Française; "Complementarity and Long-Range Projections", by J.P. Verdoorn in Econometrica, October 1956.

** This proposition will obviously not hold good to the same extent for all sectors, and for agriculture, in particular, the correlation will be inverted.

$$\log (Lik/L) = \log a + b \log (Li/L) + 1 \log (Xi/Li)$$

and, on the other hand, for Li/L and any one of the economic indicators, using the step-wise system.

2. ANALYSIS OF RESULTS

i) Levels of education in the different economic sectors and technological indicators

Having regard to the results already obtained by Layard and Saigal in this field, rather mediocre correlations might be expected between Lik/Li and the technological indicators. The only direct comparisons possible between our correlations and those of Layard are set forth in the following table:

CORRELATION COEFFICIENT R	MANUFAC.		COMMERCE		TRANSPORT		SERVICE	
	LSE	OECD	LSE	OECD	LSE	OECD	LSE	OECD
University level or above	-	0.56	-	0.20	-	0.20	-	0.40
Completed secondary or above	0.51	0.61	0.44	0.45	0.10	0.36	0.79	0.56

SOURCES: Layard and Saigal, op. cit., p. 262, Table 3.
OECD, Table IV-1.

Allowing for the number of observations (18 at university level and 13 at secondary level), these results are rather poor. The high degree of correlation between the proportion of people with completed secondary level and the level of productivity in the services sector should, however, be noted.

The entire set of simple regression equations between Lik/Li and the technological variables is shown in Table IV-1. The only significant fits are found at the "more than eight years' schooling or less" levels. The lack of any significant fit in the transport sector will be noted. As regards the explanatory variables, in the last resort it is sectoral productivity which gives the best results, except for services, where the best fits are obtained for the "social" index (Is).

The following example may possibly explain these poor correlations: in manufacturing, productivity in Israel is three times as high as in the Philippines, while the proportion of manpower with completed secondary level education in this sector (Lik/Li) is roughly the same in both countries - between 5 and 5.5%. At the same time, Lik/Li = Lik/L : Li/L; and the last two percentages are twice as high in Israel as in the Philippines. This shows how "normal" relative positions of two countries for the sectoral structure of employment (Li/L), as for Lik/L, may coexist with "aberrant" positions for Lik/Li.

Table IV-1. SIMPLE REGRESSION EQUATIONS LINKING THE LEVELS OF EDUCATION IN SOME ECONOMIC SECTORS (Lik/Li) TO ECONOMIC INDICATORS (n_i)

$$\log (Lik/Li) = \log a + b \log (n_i)$$

ECONOMIC SECTORS	EXPLANATORY VARIABLES	DEGREE LEVEL AND ABOVE (A)				COMPLETED SECONDARY SCHOOLING AND ABOVE (B)				MORE THAN EIGHT YEARS OF SCHOOLING (C)				EIGHT YEARS OF SCHOOLING AND LESS (D)			
		N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Manufacturing	XI/Li	16	0,56*	-2,01	0,63(0,23)	13	0,61	-2,03	0,90(0,36)	10	0,84*	-1,33	0,81(0,18)	10	-0,79*	2,77	-0,29(0,08)
	Index	16	0,46	-0,82	0,63(0,38)	13	0,58	-0,80	1,00(0,41)	10	0,75*	-0,07	0,93(0,34)	10	-0,75*	2,42	-0,39(0,11)
	Energy	16	0,53	-1,00	0,35(0,14)	13	0,62	-0,65	0,52(0,20)	10	-0,78*	-0,11	0,49(0,14)	10	-0,81*	2,38	-0,19(0,05)
Commerce	XI/Li	16	0,20	-0,67	0,21(0,28)	11	0,45	-0,94	0,61(0,40)	10	0,81*	-1,46	0,65(0,22)	10	-0,83*	3,56	-0,52(0,12)
Transport	XI/Li	16	0,20	0,73	-0,24(0,30)	13	0,36	-0,51	0,43(0,36)	10	0,56	-0,16	0,46(0,24)	10	-0,68	2,82	-0,30(0,11)
	Commercial Vehicles	16	0,09	0,02	-0,00(0,15)	13	0,43	0,56	0,31(0,19)	10	0,48	1,09	0,10(0,12)	10	-0,57	1,90	-0,12(0,09)
Services	X/P	16	0,40	0,27	0,21(0,13)	13	0,50	0,31	0,41(0,16)	10	0,66	0,79	0,23(0,11)	10	-0,73*	2,43	-0,20(0,08)
	"Social" Index	16	0,45	0,30	0,31(0,16)	13	0,69*	0,44	0,61(0,19)	10	0,72*	0,87	0,18(0,13)	10	-0,60	2,31	-0,30(0,11)

Before leaving Table IV-1, a point to note is the dispersion of the coefficients of elasticity between 0.80 and 1 for commerce and manufacturing*, and less than 0.50 for transport and services.

We now turn our attention to the equations linking the levels of education in the different economic sectors, as measured by Lik/L, and the technological indicators. We might expect a priori to find fairly good correlations with productivity for such sectors as manufacturing, transport and commerce; for services, on the other hand, the "social" indicator probably yields the best fits in view of the method of calculation.

As regards the educational structure, the numbers with a high level of education will probably increase less rapidly than the total less highly educated work force in such more "manual" sectors as manufacturing or transport. The converse will be true for the services sector, which tends to absorb a growing number of highly qualified "white collar" workers.

Table IV-2 gives an exhaustive representation of the regression equations Lik/L = f (n). The equations Lk/L = f (n), already shown in Part Three**, have been added. A study of this table shows that, to start with, the sectors are divided into two categories; the first includes manufacturing and services, for which good fits are obtained comparable to those found for the economy as a whole; on the other side, we have commerce and transport, for which the results are decidedly poor.

It will further be noted that in all sectors the correlation coefficients increase as the level of education considered becomes broader. The higher the level of education considered the more caution is needed in the use of these equations, while the precision of coefficients of elasticity is reduced. However, there is no significant correlation at the "eight years' schooling or less" level, except for the economy as a whole. A conclusion similar to that arrived at for the occupational categories must thus be drawn: the higher the level of productivity the lower the percentage of under-educated in the economy as a whole; but the distribution of this under-educated population among the different sectors seems to be specific to each country.

As regards manufacturing, the coefficients of elasticity point towards a tendency to a redistribution of manpower as classified by levels of education in favour of completed secondary level, whatever explanatory variable is considered.

In the services sector, contrary to our expectations, the proportion of manpower with "university level" education will rise less rapidly than the proportion with "completed secondary level or above" and "more than eight years' schooling", which both rise at the same rate as the development of this sector proceeds.

For the economy as a whole, the elasticities are roughly the same for the three levels of education considered. This means that the different Lk/L's increase at the same rate, or that, for example, the relationship between the numbers with a university degree and those with completed secondary education remains constant. As a result, in

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* For sectoral productivity and the social indicator only.

** Table III-2.

Table IV-2. SIMPLE REGRESSION EQUATIONS LINKING THE LEVELS OF EDUCATION IN SOME ECONOMIC SECTORS (Lik/L) TO ECONOMIC INDICATORS (n_i)

$$\log (Lik/L) = \log a + b \log (n_i)$$

ECONOMIC SECTORS	EXPLANATORY VARIABLES	DEGREE LEVEL AND ABOVE (A)				COMPLETED SECONDARY SCHOOLING AND ABOVE (B)				MORE THAN EIGHT YEARS OF SCHOOLING (C)				EIGHT YEARS OF SCHOOLING AND LESS (D)			
		N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Manufacturing	Xi/Li	18	0.66*	-4.24	1.08(0.31)	13	0.63	-4.15	1.30(0.48)	10	0.79*	-3.27	1.14(0.32)	10	0.07	0.83	0.04(0.23)
	Index	18	0.73*	-2.94	1.45(0.34)	13	0.81*	-2.73	1.88(0.42)	10	0.85*	-2.04	1.69(0.38)	10	0.41	0.45	0.37(0.29)
	Energy	18	0.73*	-2.84	0.71(0.17)	13	0.78*	-2.61	0.90(0.22)	10	0.83*	-1.80	0.79(0.19)	10	0.24	0.69	0.10(0.15)
Commerce	Xi/Li	16	0.26	-2.15	0.42(0.42)	11	0.35	-2.08	0.65(0.58)	10	0.69	-3.35	1.09(0.41)	10	-0.33	1.67	-0.28(0.28)
Transport	Xi/Li	18	0.06	-1.68	0.09(0.35)	13	0.35	-2.12	0.53(0.42)	10	0.56	-2.29	0.66(0.34)	10	-0.14	0.72	-0.10(0.24)
	Commerc. Vehicles	18	0.30	-1.66	0.22(0.17)	13	0.58	-1.03	0.49(0.21)	10	0.75*	-0.63	0.42(0.13)	10	0.34	0.27	0.11(0.11)
Services	X/P	18	0.70*	-1.22	0.49(0.13)	13	0.77*	-1.16	0.67(0.16)	10	0.90*	-0.97	0.68(0.12)	10	0.26	0.67	0.13(0.17)
	"Social" Index	18	0.76*	-0.99	0.68(0.14)	13	0.93*	-0.89	0.95(0.12)	10	0.95*	-0.55	0.90(0.11)	10	0.34	0.69	0.21(0.21)
Whole Economy	X/L	25	0.65*	-2.10	0.74(0.18)	21	0.75*	-1.60	0.81(0.16)	17	0.84*	-1.24	0.79(0.13)	17	-0.85*	2.72	-0.40(0.06)
	Index	25	0.71*	-1.43	1.09(0.22)	21	0.76*	-0.69	1.09(0.22)	17	0.81*	-0.40	1.12(0.21)	17	-0.86*	2.44	-0.27(0.04)
	ΣI/L	22	0.57*	-1.47	0.54(0.17)	19	0.73*	-0.97	0.61(0.14)	13	0.76*	-0.49	0.56(0.14)	13	-0.83*	2.58	-0.23(0.05)

in sectors other than manufacturing and services, the proportion of manpower with university level education should grow faster than the proportion with completed secondary education, so as to restore the balance. The poor results obtained for commerce and transport do not, however, enable us to say if this is the case in these two sectors.

From any standpoint, the fact remains that the correlations in Table IV-2 fall short of what might justifiably have been expected in view of the better homogeneity obtained in sectoral analysis. It may, therefore, be interesting to make a more detailed study of a few specific cases, using graphs. We chose as an example the manufacturing sector at the university degree level which is linked to productivity in this sector by the equation:

$$\log (Lik/L) = -4.24 + \underset{(0.31)}{1.08} \log (Xi/Li) \qquad \begin{array}{l} R = 0.66 \\ N = 18 \end{array}$$

The 18 observations were recorded in Graph IV-1. The distance at which some of them lie from the line of correlation calls for some explanation. *

- The Philippines and Japan continue to be "over-educated" by comparison with the common model. As already pointed out, the cause lies mainly in the wide development of higher studies of relatively short duration (four years at college) on the American model. We also know that, at least as far as Japan is concerned, the use of exchange rates for the comparison of productivities results in the latter being greatly underestimated.

- The Netherlands, on the other hand, is much below the line, although its productivity is identical with that of Belgium, for example. Here again, the explanation lies in the must longer average duration of university study in the Netherlands. **

- In the case of Panama, productivity in manufacturing (2,500 dollars per head) is manifestly over-estimated.

- The case of Syria is very different. The value found for Xi/Li is the same as for Egypt, and therefore reasonable. On the other hand, the low numbers holding university degrees are certainly due to the fact that, until quite recently, Syria possessed no university of its own, its highly qualified manpower being generally trained at the University of Cairo.

- The over-estimation of industrial productivity in Zambia is due to the inclusion of the mining sector, which is relatively large and well equipped. ***

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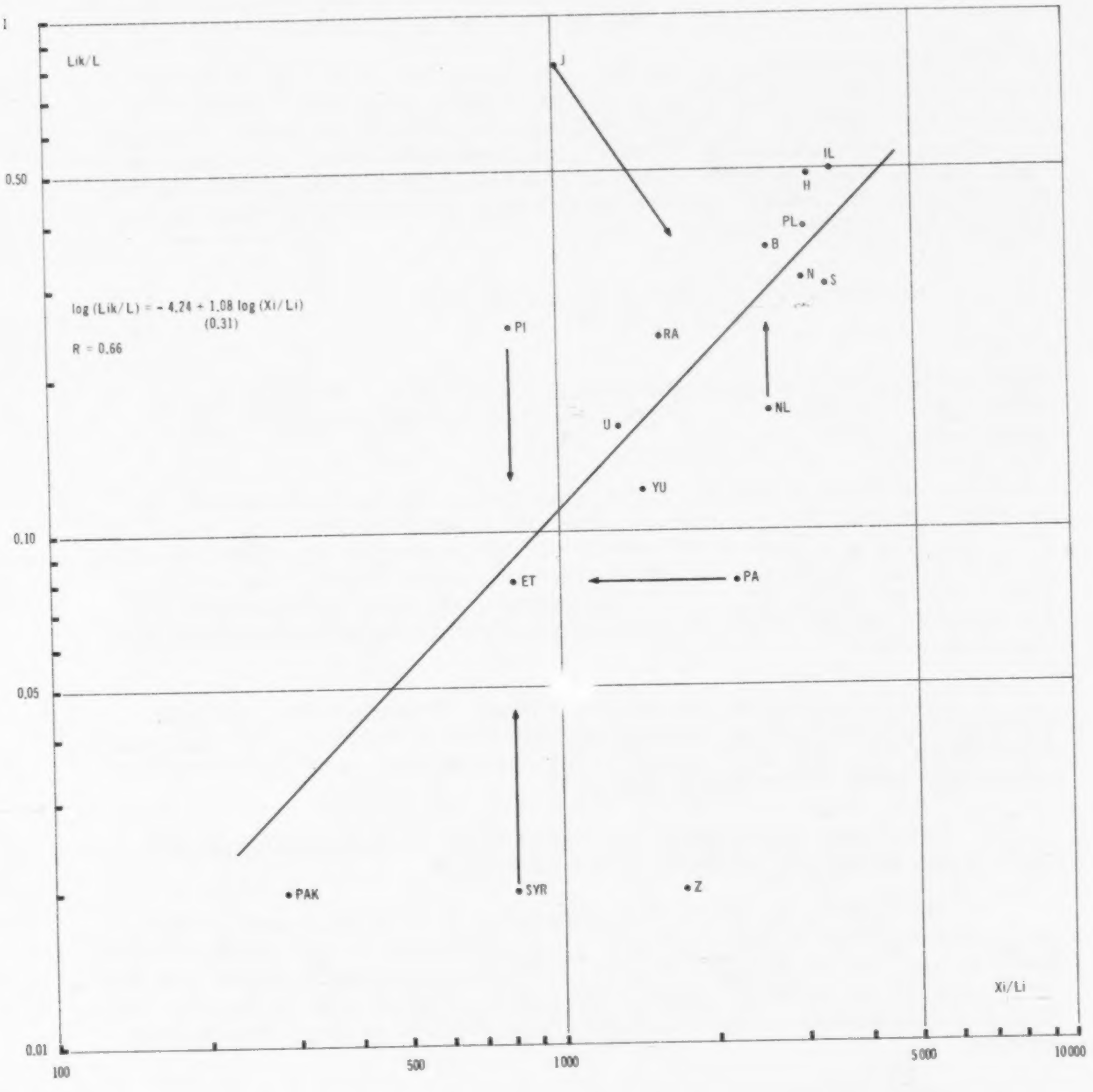
* The arrows appearing in the graph by no means constitute value judgments; they simply indicate which of the two variables involved is the more responsible for the remote position of any given country.

** It will be remembered that we did not feel justified in equating post-secondary educational qualifications with university degrees; see Annex A.

*** See Manpower Report: a Report and Statistical Handbook on Manpower, Education, Training and Zambianization 1965-66, Republic of Zambia, Lusaka, 1966.

Graph IV-1

MANUFACTURING: PERSONNEL WITH «UNIVERSITY DEGREE» AS A PROPORTION OF TOTAL EMPLOYMENT (Lik/L), AND SECTOR OUTPUT PER WORKER (Xi/Li)



If, then, it is essential to keep in mind all these statistical approximations in order to form a judgment on the correlations proposed, it may be interesting to examine a similar diagram for the level of education immediately below, in order to bring out any instances of disequilibrium or substitution between the educational stock of different levels see Graph IV-2, linking Lik/L with sectoral productivity, i representing the manufacturing sector, and k, completed secondary level or above.

It will be noted that here again Japan emerges as more highly educated than the average, but this is no longer the case for the Philippines. Panama and Zambia, which can be regarded as under-educated at university level, will also be so at completed secondary level. The manufacturing sector in Egypt, which is "normally" educated at university level, appears, on the contrary, distinctly under-educated at completed secondary level. While some "drain" of manpower with secondary qualifications might have occurred, especially to the services sector, Graph IV-3 makes it clear that this is not the case.

There may be still other reasons for these poor fits, as seems to be indicated by the Graph IV-3 showing the correlation between Lik/L (i being the services sector and k completed secondary level or above), and production per capita. This graph brings out considerable differences in Lik/L for a given level of productivity: with the Philippines and Egypt at 150 dollars per capita level, Japan and Panama at 350 dollars, and Israel and Poland at 900 to 1, 100 dollars. In addition, however, approximately the line of estimation 1 may be plotted. Four countries, in particular, lie distinctly above it - the Philippines, Japan, Israel and the United States whose educational systems have much the same structure, namely, eight years of elementary school followed by four years of high school. If these four countries are roughly fitted to line 2, we obtained a zone of correlation which any other country should be able to fit into. *

Lastly, we tested the levels of education in the different economic sectors - defined by Lik/Li and Lik/L - for the two chief technological indicators simultaneously by using the multiple regression equation:

$$\log (Lik/L) = \log a + b \log (Xi/Li) + c \log n$$

Xi/Li being replaced by X/P for the services sector.

The results, as shown in Table IV-3, are not usable. While they are sometimes better than those obtained with a simple explanatory variable, collinearity between the explanatory variables themselves causes extremely high standard deviations attached to the coefficients of elasticity.

ii) Levels of education in the different economic sectors and sectoral structure of employment

Here good and somewhat spurious fits might normally be expected, as Lik/L is contained in Li/L. In this case, the best correlations should

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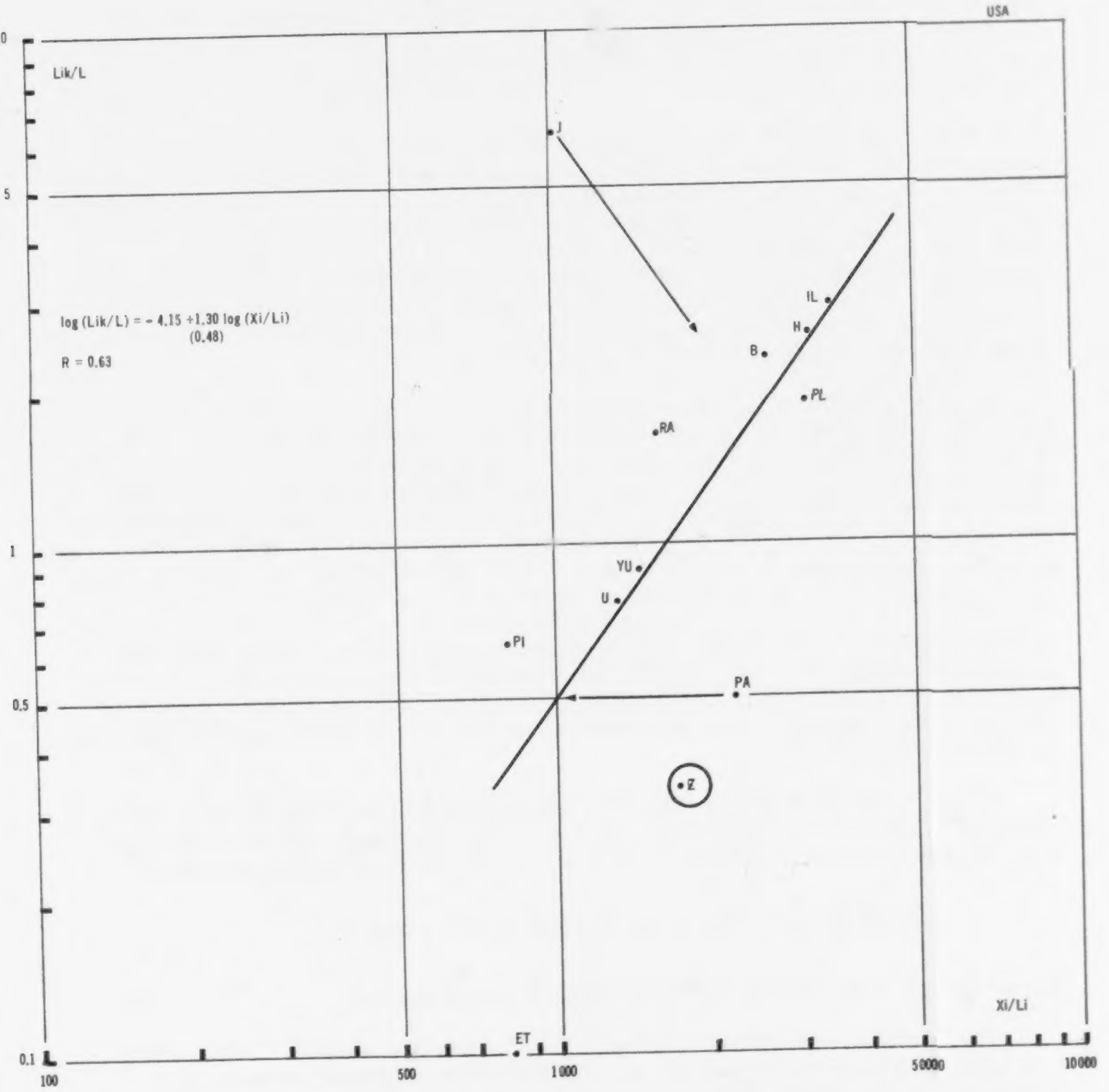
* The number of observations is here undoubtedly too small to obtain a perfect scientific example. Yet it illustrates fairly clearly the value of a graphic analysis of the scatter chart, and allows the calculation itself to be satisfactorily completed by inference.

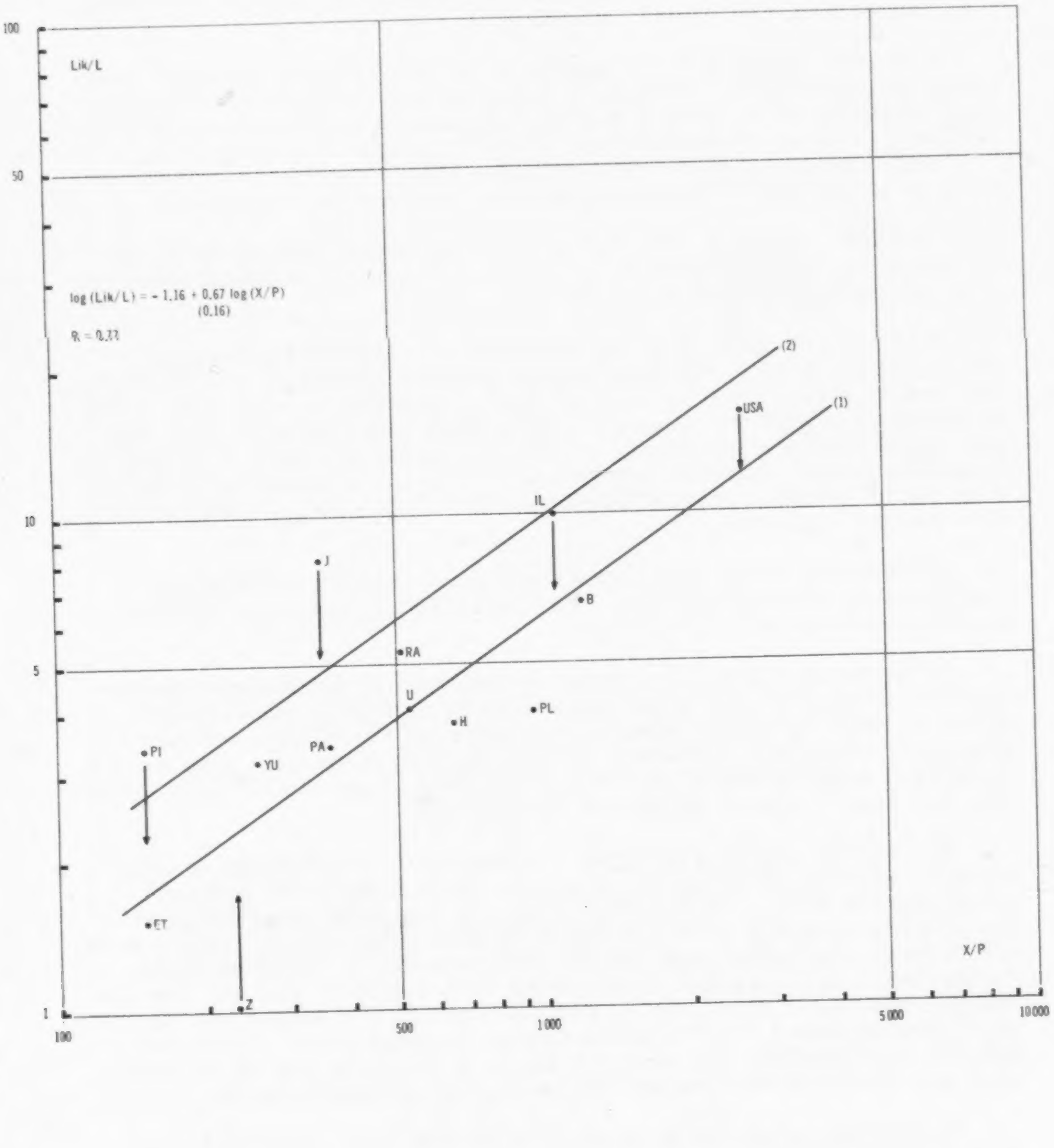
Graph IV-2

MANUFACTURING: PERSONNEL WITH «COMPLETED SECONDARY SCHOOLING AND ABOVE» AS A PROPORTION OF TOTAL EMPLOYMENT (Lik/L), AND SECTOR OUTPUT PER WORKER (Xi/Li)



Graph IV-3

SERVICES: PERSONNEL WITH «COMPLETED SECONDARY SCHOOLING AND ABOVE» AS A PROPORTION OF TOTAL EMPLOYMENT (Lik/L), AND GDP PER CAPITA (X/P)



also be found in the most clearly defined sectors as to numbers employed, i. e. manufacturing and transport. As furthermore, the explanatory variable represents the size of the sector concerned, correlations should be best for the most comprehensive level of education, i. e. "more than eight years' schooling".

Elasticity coefficients of equations Lik/L = f (Li/L) should be compared between levels of education within each sector (that is "horizontally" in Table IV-4), thus providing information on the changes of the various Lik/Li' s for each sector, when the weight of this sector in total employment changes: an elasticity equal, superior or inferior to one means that Lik/Li remains constant, increases or decreases.

This being granted, the results of the equations linking the levels of education in the different economic sectors and the sectoral structure of employment are shown in Table IV-4.

In this case, fairly good correlations are obtained for manufacturing and commerce, but they remain poor for transport, except at the "more than eight years' schooling" level. In services, the latter level of education is also the only one to show good correlation with the sectoral structure of employment, which is more surprising. The likely expansion is that, in many developing countries, employment in the tertiary sector tends to expand faster than the educational system* or even the economy as a whole.

Another fact which may cause surprise is that the correlations at "eight years' schooling or less" level should be so positive. The only possible interpretation is as follows.

If, as we have seen, the levels of education in the different sectors improve as employment rises, growth of employment will still leave plenty of room for an increase in the number of relatively uneducated manpower which will, however, be less rapid in all sectors than the increases at other levels of education; the coefficients of elasticity, which are less than 1, are all between 0. 70 and 0. 80.

The results obtained here from a study of the coefficients of elasticity by sectors differ appreciably from those found in the previous paragraph for Xi/Li. In manufacturing, for instance, elasticities at the first three levels of education are roughly equal to 1. 5. This means, it will be remembered, that (a) the general level of education in the sector is rising faster than employment in that sector, and (b) that the relative weights of each level of education within this sector remain the same (the various Lik/Li' s increasing at the same rate). From this aspect, the manufacturing sector behaves in the same way as the economy as a whole in relation with the technological indicators. **

In commerce, on the other hand, there will be a slight redistribution in favour of numbers with a university degree, and a relative drop

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* At least at higher level. Another explanation might be that services attract only a small proportion of the total number of qualified workers; but all the available data about their distribution by sectors tend to prove the opposite.

** See the elasticities in the equation Lk/L = f (n) in Table IV-2: for the first three levels of education, they are roughly equal to 0. 75-0. 80. If therefore the rate of change is the same for the first three percentages Lk/L's, the ratios of one Lk/L over the other are bound to remain constant.

Table IV-3. MULTIPLE REGRESSION EQUATIONS LINKING THE LEVELS OF EDUCATION IN SOME ECONOMIC SECTORS (Lik/L, Lik/Li) TO TWO ECONOMIC INDICATORS

ECONOMIC SECTORS		DEGREE LEVEL AND ABOVE (A)				COMPLETED SECONDARY SCHOOLING AND ABOVE (B)				MORE THAN EIGHT YEARS OF SCHOOLING (C)				EIGHT YEARS OF SCHOOLING AND LESS (D)			
		R	log a	b(σ b)	c(σ c)	R	log a	l(σ b)	c(σ c)	R	log a	b(σ b)	c(σ c)	R	log a	b(σ b)	c(σ c)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Manufacturing[1]	Lik/L	0, 73	-2, 68	-0, 10(0, 71)	0, 76(0, 42)	0, 78	-2, 27	-0, 18(0, 75)	0, 99(0, 42)	0, 83	-1, 94	0, 09(0, 86)	0, 73(0, 66)	0, 51	1, 92	-0, 82(0, 60)	0, 60(0, 39)
	Lik/Li	0, 56	-1, 90	0, 55(0, 59)	0, 05(0, 35)	0, 64	-1, 47	0, 44(0, 67)	0, 31(0, 38)	0, 84	-1, 33	0, 81(0, 56)	0, 00(0, 37)	0, 82	2, 54	-0, 10(0, 22)	-0, 13(0, 14)
Transport[2]	Lik/L	0, 36	-0, 56	-0, 39(0, 47)	0, 35(0, 24)	0, 58	-0, 96	-0, 03(0, 49)	0, 50(0, 28)	0, 76	-1, 02	0, 14(0, 39)	0, 38(0, 18)	0, 59	1, 56	-0, 45(0, 28)	0, 25(0, 14)
	Lik/Li	0, 21	0, 90	-0, 31(0, 42)	0, 05(0, 21)	0, 44	0, 07	0, 18(0, 46)	0, 24(0, 26)	0, 58	0, 09	0, 35(0, 34)	0, 08(0, 16)	0, 70	2, 67	-0, 24(0, 16)	-0, 04(0, 07)
Services[3]	Lik/L	0, 76	-1, 02	0, 04(0, 27)	0, 64(0, 34)	0, 93	-0, 93	0, 04(0, 18)	0, 92(0, 21)	0, 95	-0, 69	0, 16(0, 22)	0, 72(0, 28)	0, 36	0, 82	-0, 15(0, 43)	0, 38(0, 53)
	Lik/Li	0, 45	0, 38	-0, 02(0, 30)	0, 35(0, 38)	0, 70	0, 47	-0, 03(0, 29)	0, 63(0, 35)	0, 72	0, 92	0, 05(0, 28)	0, 33(0, 35)	0, 75	2, 42	-0, 25(0, 22)	-0, 02(0, 27)
Whole Economy[4]	Lk/L	0, 64	-2, 28	1, 03(0, 61)	-0, 24(0, 49)	0, 73	-1, 31	0, 44(0, 53)	0, 28(0, 43)	0, 81	-1, 12	0, 81(0, 54)	-0, 07(0, 43)	0, 86	2, 77	-0, 25(0, 18)	-0, 04(0, 14)

NOTES: Explanatory variables are identical for both dependent variables in each sector.

We have in succession:
(1) log Lik/L = log a + b log (Xi/Li) + c log Energy
(2) log Lik/L = log a + b log (Xi/Li) + c log Commercial Vehicles
(3) log Lik/L = log a + b log (X/P) + c log Is
(4) log Lk/L = log a + b log (X/L) + c log (Σ I/L).

Table IV-4. SIMPLE REGRESSION EQUATIONS LINKING THE LEVELS OF EDUCATION IN SOME ECONOMIC SECTORS (Lik/L) TO THE SECTORAL STRUCTURE OF EMPLOYMENT (Li/L)

log (Lik/L) = log a + b log (Li/L)

ECONOMIC SECTORS	DEGREE LEVEL AND ABOVE (A)				COMPLETED SECONDARY SCHOOLING AND ABOVE (B)				MORE THAN EIGHT YEARS OF SCHOOLING (C)				EIGHT YEARS OF SCHOOLING OR LESS (D)			
	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Manufacturing	18	0, 78*	-2, 66	1, 57(0, 31)	13	0, 73*	-1, 69	1, 48(0, 42)	10	0, 80*	-1, 36	1, 55(0, 42)	10	0, 86*	0, 12	0, 77(0, 15)
Commerce	17	0, 79*	-2, 23	1, 51(0, 30)	12	0, 71*	-1, 24	1, 38(0, 44)	10	0, 78*	-0, 89	1, 33(0, 38)	10	0, 75*	0, 10	0, 69(0, 21)
Transport	18	0, 52	-1, 99	0, 91(0, 38)	13	0, 53	-1, 15	1, 18(0, 57)	10	0, 72*	-0, 79	1, 21(0, 41)	10	0, 81*	-0, 04	0, 80(0, 21)
Services	18	0, 59*	-1, 00	0, 90(0, 31)	13	0, 54	-0, 34	0, 79(0, 38)	10	0, 85*	-0, 83	1, 29(0, 29)	10	0, 75*	0, 08	0, 74(0, 23)

at "eight years' schooling or less" level; the elasticity for the first is twice for the second.

In transport, however, redistribution tends to favour the "completed secondary" and "more than eight years' schooling" levels, with an elasticity of close on 1.20; while numbers at the "extreme" levels* will rise at practically the same rate with an elasticity of 0.8 and 0.9.

In services only numbers at the "more than eight years' schooling" and "eight years' schooling or less" levels exhibit any specific trend: as employment in the tertiary sector rises, redistribution will favour the former. Our results are not, however, sufficiently precise to enable the pattern of internal redistribution for those with "more than eight years' schooling" to be determined.

iii) Levels of education in the different economic sectors, sectoral structure of employment and technological indicators

a) As a first stage, we tried to test levels of education in the different economic sectors both for the sectoral structure of employment and labour productivity. The latter remains the most convenient indicator of the level of technology attained in any one sector, while the former indicates the volume of employment in that sector, hence, as it were, its capacity to attract manpower of a given level of qualification. Bearing the complementarity of these two types of explanatory variables in mind, a test was therefore made for:

$$Lik/L = f\,(Xi/Li,\ Li/L).$$

The results are shown in Table IV-5.

The first obvious conclusion is that, as a whole, these correlations are distinctly better than when Xi/Li or Li/L are considered separately. The results are particularly good for manufacturing, commerce and services, but remain poor for transport at university and completed secondary levels. If levels of education are considered, the best correlations ($R > 0.90$) are obtained for "more than eight years' schooling" and "eight years' schooling or less".

The standard deviations for the coefficients of elasticity are still, however, so great as to render these coefficients unusable, especially at "university degree level" and "completed secondary level or above", but with the exception of the manufacturing sector. Confirming what has already been said about the quality of the fits, the coefficients of elasticity are more precise for the other two levels of education. Generally speaking, the elasticities are higher in relation to Li/L than in relation to Xi/Li; in the second case, they are, in fact, negative at the "eight years' schooling or less" level, which means that, as productivity rises, the proportion in the sector with this level of education diminishes, while the relative weight of this sector in total employment remains constant.

b) To remedy this lack of precision in the coefficients of elasticity, the step-wise system was used, prescribing as the explanatory variable the sectoral structure of employment (Li/L), leaving the computer free to choose the technological indicator: Xi/Li or the non-monetary indicator.

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* University degree and "eight years' schooling or less".

Table IV-5. MULTIPLE EQUATIONS LINKING THE LEVELS OF EDUCATION IN SOME ECONOMIC SECTORS (Lik/L)

TO { SECTOR OUTPUT PER WORKER, AND
THE SECTORAL STRUCTURE OF EMPLOYMENT

$$\log (Lik/L) = \log a + b \log (Xi/Li) + c \log (Li/L)$$

ECONOMIC SECTORS	DEGREE LEVEL AND ABOVE (A)				COMPLETED SECONDARY SCHOOLING AND ABOVE (B)				MORE THAN EIGHT YEARS OF SCHOOLING (C)				EIGHT YEARS OF SCHOOLING AND LESS (D)			
	R	log a	b(σ b)	c(σ c)	R	log a	b(σ b)	c(σ c)	R	log a	b(σ b)	c(σ c)	R	log a	b(σ b)	c(σ c)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Manufacturing ..	0, 83	-3, 96	0, 54(0, 28)	1, 21(0, 35)	0, 82	-4, 04	0, 84(0, 40)	1, 16(0, 40)	0, 93	-3, 34	0, 78(0, 22)	1, 09(0, 30)	0, 95	0, 77	-0, 26(0, 09)	0, 92(0, 12)
Commerce	0, 81	-2, 64	0, 11(0, 27)	1, 54(0, 32)	0, 78	-3, 28	0, 59(0, 41)	1, 39(0, 44)	0, 92	-3, 47	0, 83(0, 24)	1, 09(0, 26)	0, 93	1, 58	-0, 48(0, 12)	0, 82(0, 13)
Transport	0, 54	-1, 25	-0, 25(0, 34)	1, 04(0, 42)	0, 61	-2, 55	0, 44(0, 38)	1, 10(0, 56)	0, 81	-2, 19	0, 46(0, 27)	1, 02(0, 39)	0, 90	0, 81	-0, 28(0, 12)	0, 91(0, 17)
Services	0, 73	-1, 44	0, 38(0, 18)	0, 43(0, 33)	0, 80	-1, 35	0, 55(0, 18)	0, 36(0, 31)	0, 93	-1, 11	0, 46(0, 18)	0, 56(0, 35)	0, 92	0, 33	-0, 42(0, 12)	1, 40(0, 24)

NOTE: For the Services Sector, the output per worker (Xi/Li) in this sector has been replaced by GDP per capita (X/P).

The results obtained do not affect the conclusions in the previous paragraph; in certain cases, however, a non-monetary indicator may be substituted for productivity. Thus, for manufacturing, we obtain:

$$\log(\mathrm{Lik}/\mathrm{L}) = -2,08 + \underset{(0,18)}{0,52}\log(\mathrm{Energy}) + \underset{(0,38)}{0,91}\log(\mathrm{Li}/\mathrm{L}) \qquad \bar{R} = 0,91$$

k = more than eight years' schooling

$$\log(\mathrm{Lik}/\mathrm{L}) = 0,38 - \underset{(0,07)}{0,19}\log(\mathrm{Energy}) + \underset{(0,13)}{1,00}\log(\mathrm{Li}/\mathrm{L}) \qquad \bar{R} = 0,95$$

k = eight years' schooling or less

Whatever technological indicator is used, it is mainly the size of the sector which seems to determine the educational structure of employment. Furthermore, the countries in our sample do not seem to follow any common pattern at the "university degree" or "completed secondary education or above" levels. The inclusion of two explanatory variables (technological indicator and size of sector) does not, therefore, seem justified at these levels.

XVI

LEVELS OF EDUCATION IN THE DIFFERENT ECONOMIC SECTORS AND EDUCATIONAL STRUCTURE OF THE LABOUR FORCE

I. INTRODUCTION AND BASIC ASSUMPTIONS

Having examined how and to what extent the technological indicators or the sectoral structure of employment can influence levels of education in the different economic sectors, let us now consider how far those levels are determined by the available supply of qualified manpower at all levels in the labour force. As pointed out in Part Three, we do not know the number of qualified workers actually available among the population of working age; we only know the educational structure of the labour force, i.e., the numbers of qualified workers remaining after indirect "screening" through the rates of activity. We have already dealt at length with the possibilities and limitations of such an approximation* and shall not return to the matter here.

This being stated, the purpose of our analysis is not so much to show how far the levels of education in the different sectors are "explained" by the available supply of qualified manpower at different levels** than to gain some idea as to how qualified workers are distributed among the different sectors of the economy.

As a more practical approach, the levels of education in the different economic sectors will be tested for the educational structure of the total labour force (Lk/L), using the following simple regression equation:

$$\log (Lik/L) = \log a + b \log (Lk/L)$$

This equation will also be tested for Lik/Li as a dependent variable.

On the basis of the results of the analysis of educational levels in the different occupational categories, one very similar to the present analysis, good and somewhat spurious fits may be looked for between Lik/L and Lk/L. It may further be assumed that certain sectors such as manufacturing and commerce will tend to absorb more than their fair share of qualified manpower.*** The services sector may find instead that its stock of qualified manpower rises less rapidly, as even in countries where the aggregate number of qualified workers is relatively small this sector already tends to absorb a large proportion.

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* See Part Three, Chapter XII.

** Spurious correlations would make the operation hazardous.

*** In statistical terms, those sectors will have an elasticity higher than 1.

2. ANALYSIS OF RESULTS

Table IV-6 contains all the simple regression equations linking the levels of education in the different economic sectors and the educational structure of the total labour force.

As expected, correlations on the whole, are excellent both for Lik/L and for Lik/Li, with a slight advantage in favour of the first of these two variables. Taking the sectors separately, only transport shows a few coefficients under 0.80 with Lik/Li as the dependent variable. Taking the different levels of education, there is no significant link between Lik/L and Lk/L, where k represents "eight years' schooling or less".

When comparing elasticity coefficients of equations $Lik/L = f\,(Lk/L)$ in Table IV-6 "vertically", one gets an insight into the distribution of workers having a given educational level through sectors: thus manufacturing tends to absorb larger numbers than the other sectors, with elasticities approaching 1.5 at university level and completed secondary level. The same applies to commerce, where the elasticities reach 1.2 for these same levels, and transport, with 1.1 and 1.15 respectively. To offset all these coefficients higher than 1, the relative increase in the number of qualified workers in other sectors must be less than proportional to the increase in the total numbers of qualified workers. This applies in particular to the services sector, where all elasticities lie between 0.8 and 0.9. It is thus worth noting that the improvement in the educational structure of employment accompanying economic development coincides, on the one hand, with the familiar process of employment growth in tertiary activities and, on the other hand, with a redistribution of qualified manpower in favour of the secondary sectors.* In this connection, the fact often noted in certain developing countries that the majority of qualified workers are in services reliably points to a malutilization of qualified manpower, a condition which should gradually be remedied as development proceeds. These considerations hold true for the three levels: "university degree", "completed secondary" and "more than eight years' schooling", whatever dependent variable is taken.

Turning now to equations $Lik/Li = f\,(Lk/L)$, we will observe for instance that the proportion of manpower with eight years' schooling or less (Lik/Li) in services declines at the same rate as the proportion in the total active population, with an elasticity equal to 1. The proportion declines faster for commerce, thus tending to correct this sector's adverse initial position, due, as we know, to the inclusion of a varying proportion of the totally or relatively uneducated, especially in street peddling. The converse applies for the manufacturing sector and for transport.

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* More particularly, the manufacturing sector and, to a lesser degree, commerce and transport.

Table IV-6. SIMPLE REGRESSION EQUATIONS LINKING THE LEVELS OF EDUCATION IN SOME ECONOMIC SECTORS (Lik/L, Lik/Li) TO THE EDUCATIONAL STRUCTURE OF THE LABOUR FORCE (Lk/L)

$\log(Lik/L) = \log a + b \log(Lk/L)$; $\log(Lik/Li) = \log a + b \log(Lk/L)$

ECONOMIC SECTORS		DEGREE LEVEL AND ABOVE (A)				COMPLETED SECONDARY SCHOOLING AND ABOVE (B)				MORE THAN EIGHT YEARS OF SCHOOLING (C)				EIGHT YEARS OF SCHOOLING AND LESS (D)			
		N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)	N	R	log a	b(σ b)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Manufacturing	Lik/L	18	0,93*	-1,14	1,48(0,14)	13	0,97*	-1,27	1,45(0,11)	10	0,96*	-1,10	1,28(0,14)	10	-0,20	1,57	-0,32(0,54)
	Lik/Li	18	0,90*	-0,23	0,98(0,12)	13	0,86*	-0,02	0,92(0,17)	10	0,86*	0,38	0,77(0,16)	10	0,92*	0,37	0,80(0,12)
Commerce	Lik/L	17	0,91*	-1,07	1,23(0,14)	12	0,93*	-1,07	1,24(0,15)	10	0,94*	-0,91	1,09(0,14)	10	0,05	0,59	0,08(0,57)
	Lik/Li	17	0,85*	0,07	0,77(0,12)	12	0,81*	0,38	0,79(0,18)	10	0,81*	0,71	0,62(0,16)	10	0,95*	-0,33	1,14(0,13)
Transport	Lik/L	18	0,90*	-1,68	1,10(0,13)	13	0,98*	-1,51	1,17(0,08)	10	0,99*	-1,21	0,96(0,05)	10	0,07	0,22	0,10(0,53)
	Lik/Li	18	0,63*	-0,23	0,66(0,20)	13	0,82*	0,16	0,83(0,17)	10	0,76*	0,73	0,52(0,16)	10	0,96*	0,18	0,89(0,09)
Services	Lik/L	18	[illegible]	-0,16	0,90(0,05)	13	0,95*	-0,14	0,81(0,08)	10	0,96*	-0,20	0,84(0,09)	10	0,10	0,71	0,15(0,52)
	Lik/Li	18	0,81*	0,71	0,60(0,11)	13	0,82*	0,85	0,60(0,13)	10	0,89*	1,03	0,45(0,08)	10	0,94*	-0,09	0,99(0,13)

In conclusion, it seems undeniable that the level of education in the different economic sectors, however expressed, largely depends on the available supply of qualified manpower at all levels, i.e., on the past and present development of the educational system. This evidence re-enforces therefore the conclusion reached at the end of Chapter XII (Part Three) with regard to the existence and importance of educational supply effects.

XVII

LEVELS OF EDUCATION IN THE DIFFERENT ECONOMIC SECTORS, TECHNOLOGICAL INDICATORS, SECTORAL AND EDUCATIONAL STRUCTURE OF THE LABOUR FORCE

1. OBJECT OF THE ANALYSIS

We must now link the analysis carried out in Chapters XV and XVI to situate our investigations in a context more closely approaching reality, where the influence of the different variables combines to modify the levels of education in the different economic sectors. In our opinion, these levels should depend both on the level of technology reached and on the available supply of qualified manpower at different levels. As we see it, it is these two types of influence combined which should mainly determine levels of education by sectors.

The levels will therefore be tested in turn;

a) for the technological indicators and the educational structure of the labour force, simultaneously;

b) for the sectoral and educational structure of the labour force.

The multiple regression equation used will be in double-logarithmic form; this gives in turn, for (a):

$$\log (Lik/L) = \log a + b \log (Lk/L) + c \log n$$

$$\log (Lik/Li) = \log a + b \log (Lk/L) + c \log n$$

and for (b):

$$\log (Lik/Li) = \log a + b \log (Lk/L) + c \log (Li/L).$$

We have already explained why this dependent variable was preferable to Lik/L, and why in any event it is needless to employ the two dependent variables in turn whenever Li/L is included among the explanatory variables.*

These different equations should, in theory, enable us (a) to improve the correlations obtained with each explanatory variable separately, and (b) to determine what type of variable best "explains" the levels of education in the different economic sectors.

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* See Part Three, page 169.

In the light of what we already know about the relationships existing between Lik/L and n, Lik/L and Li/L on the one hand, and Lik/Li and Lk/L on the other, it may here again be assumed that (a) the available supply of qualified manpower will explain Lik/L distinctly better than the technological indicators, and (b) that there should be a fairer division of influence between Lk/L and Li/L.

We shall attempt to verify these two assumptions in the following sections.

2. LEVELS OF EDUCATION IN THE DIFFERENT ECONOMIC SECTORS, TECHNOLOGICAL INDICATORS AND EDUCATIONAL STRUCTURE OF THE LABOUR FORCE

We began by working out a first set of equations using as explanatory variables the educational structure of the total labour force and sectoral labour productivity, taking Lik/L and Lik/Li in turn as dependent variables.

The results, are presented in Table IV-7. While in most cases the correlations are better than with the single explanatory variable Lk/L (see Table IV-6), there is usually little improvement. And as before, the coefficients of elasticity are ambiguous owing to very considerable standard deviations, especially for labour productivity. A few equations drawn from Table IV-7 are shown below. It should be noted that some of them relate to sectors like commerce and transport for which few results have hitherto been obtained.

Thus, for commerce at the "eight years' schooling or less" level we obtain:

$$\log(\mathrm{Lik/Li}) = -0.77 + \underset{(0.15)}{0.88}\log(\mathrm{Lk/L}) - \underset{(0.08)}{0.18}\log(\mathrm{Xi/Li}) \qquad R = 0.98$$

Similarly, for transport at "university degree" level we get:

$$\log(\mathrm{Lik/Li}) = -0.77 + \underset{(0.13)}{1.17}\log(\mathrm{Lk/L}) - \underset{(0.14)}{0.28}\log(\mathrm{Xi/Li}) \qquad R = 0.92$$

Lastly, for services, at "more than eight years' schooling" we obtain:

$$\log(\mathrm{Lik/Li}) = 1.48 + \underset{(0.15)}{0.80}\log(\mathrm{Lk/L}) - \underset{(0.13)}{0.34}\log(\mathrm{X/P}) \qquad R = 0.95$$

The high standard deviations cannot be traced back, it seems, to collinearity between the explanatory variables, as R = 0.06 in manufacturing, 0.27 in transport, 0.38 in commerce, and 0.69 in servies.

Furthermore, a glance at Table IV-7 shows that only the elsticities in relation to Lk/L are determined with any real accuracy, whence the idea of replacing Xi/Li by another technological indicator. The same equations were, therefore, worked out again by the step-wise system, i.e., by allowing the computer to choose the variables giving the best fits.

The most interesting equations are given below:

In the manufacturing sector at "completed secondary level or above" we obtain:

$$\log (Lik/L) = -1.75 + \underset{(0.13)}{1.25} \log (Lk/L) + \underset{(0.10)}{0.22} \log (\text{Energy}) \qquad R = 0.98$$

In transport at "university degree level":

$$\log (Lik/Li) = 0.20 + \underset{(0.18)}{1.07} \log (Lk/L) - \underset{(0.11)}{0.42} \log (\text{Com. Veh.}) \qquad R = 0.84$$

In services at "completed secondary level or above":

$$\log (Lik/L) = -0.52 + \underset{(0.15)}{0.49} \log (Lk/L) + \underset{(0.18)}{0.43} \log (\text{index}) \qquad R = 0.97$$

These few examples show that (a) the physical indicators are chosen in preference to labour productivity, and (b) this does not appreciably change the results. The available supply of qualified manpower (Lk/L) is still the most precisely determined variable; there can be no doubt that it explains a major part of the variance of the levels of education in the different economic sectors. In other words, the mere presence of qualified manpower at different levels on the labour market would suffice to shape the pattern of education in the different economic sectors, the "requirements" arising from the level of technology achieved playing only a very minor part.

However, one last objection might be made: the very "form" of the variables Lik/L and Lk/L, which are both percentages of the same L base, may lead to artificial correlations which have no connection with reality. We shall accordingly try, in the next section, to replace the technological indicators by a variable that will dispose of this objection.

3. EDUCATIONAL PROFILES OF THE DIFFERENT ECONOMIC SECTORS, SECTORAL AND EDUCATIONAL STRUCTURE OF THE LABOUR FORCE

We shall now attempt to explain the educational profile of the different economic sectors through both the sectoral and the educational structure of the labour force. This approach forms a logical sequel to the previous analyses, in which, it will be remembered, the sectoral structure of employment was regarded as a substitute for the sectoral technological indicators.

We shall use for this purpose a multiple regression equation in the form:

$$\log (Lik/Li) = \log a + b \log (Li/L) + c \log (Lk/L)$$

excluding the equations with Lik/L as a dependent variable.

There are two reasons for this:

a) Although, on the whole, the correlations between Lik/Li and Lk/L taken alone are very good, they leave room for possible improvements by the addition of another explanatory variable. *

b) The Lik/Li percentage is mathematically independent of Li/L and Lk/L, while this is not the case for Lik/L, which is always lower than the smaller of the two.

The results of this equation are shown in Table IV-8. it will be noted that most of the correlations are excellent: in most cases the multiple correlation coefficient is higher than 0, 90.

Generally speaking, the elasticities for Lk/L are more specific than those for Li/L, which moreover are negative whenever Lik/Li is taken as the dependent variable. This should cause no surprise, since, if Lk/L is kept constant while Li/L, i.e., the aggregate number employed in this sector, rises, the proportion of educated manpower in this sector (Lik/Li) must necessarily decline. Conversely, at the "eight years' schooling or less" level, if Lk/L is kept constant while Li/L rises, the proportion of the relatively uneducated will rise in correlation with the aggregate number employed. Hence the positive coefficients of elasticity for Li/L.

The equations in Table IV-8 make possible a description of the future trend of the educational profile in each sector.

- Thus, for manufacturing, when Lk/L and Li/L rise by 1% respectively, Lik/Li will increase faster at university level (0.8%) than at the "completed secondary or above" and "more than eight years' schooling" levels (0.5% respectively). There will thus be a marked redistribution of the labour force in favour of university graduates as development proceeds.

These results are not contradicted by those obtained at the "eight years' schooling or less" level; taking Lik/Li as the dependent variable, we obtain:

$$\log (Lik/Li) = 0,16 + \underset{(0,16)}{0,87} \log (Lk/L) + \underset{(0,09)}{0,07} \log (Li/L) \qquad R = 0,98$$

The elasticity for Li/L not being significant, we shall have to make do with:

$$\log (Lik/Li) = 0,37 + \underset{(0,12)}{0,80} \log (Lk/L) \qquad R = 0,92$$

(see Table IV-6)

The proportion of relatively uneducated people in the sector will thus decline as the general level of education of the active population rises.

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* See Table IV-6.

Table IX-7. MULTIPLE REGRESSION EQUATIONS LINKING THE LEVELS OF EDUCATION IN SOME ECONOMIC SECTORS (Lik/L, Lik/Li)

TO {SECTOR OUTPUT PER WORKER AND
THE EDUCATIONAL STRUCTURE OF THE LABOUR FORCE

log (Lik/Li) = log a + b (Lk/L) + c log (Xi/Li) and log (Lik/Li) = log a + b log (Lk/L) + c log (Xi/Li)

ECONOMIC SECTORS		HIGHER LEVEL AND ABOVE (A)				COMPLETED SECONDARY SCHOOLING AND ABOVE (B)				MORE THAN EIGHT YEARS OF SCHOOLING (C)				EIGHT YEARS OF SCHOOLING AND LESS (D)			
		R	log a	b(σ b)	c(σ c)	R	log a	b(σ b)	c(σ c)	R	log a	b(σ b)	c(σ c)	R	log a	b(σ b)	c(σ c)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Manufacturing	Lik/L	0,86	-1,58	1,40(0,18)	0,11(0,20)	0,87	-1,63	1,17(0,13)	0,19(0,18)	0,86	-0,67	1,43(0,28)	-0,19(0,30)	0,26	2,71	-0,64(0,95)	-0,17(0,39)
	Lik/Li	0,80	-0,05	1,20(0,18)	-0,08(0,17)	0,87	-0,93	0,82(0,21)	0,23(0,20)	0,88	-0,48	0,47(0,31)	0,38(0,34)	0,92	0,79	0,68(0,21)	-0,06(0,09)
Commerce	Lik/L	0,81	-0,40	1,58(0,13)	-0,18(0,18)	0,84	-1,08	1,22(0,17)	0,18(0,24)	0,95	-1,62	0,98(0,18)	0,25(0,24)	0,44	3,74	-0,65(0,79)	-0,53(0,42)
	Lik/Li	0,80	0,38	0,81(0,14)	-0,15(0,18)	0,83	-0,33	0,73(0,20)	0,28(0,28)	0,90	-0,78	0,38(0,16)	0,52(0,22)	0,98	-0,77	0,88(0,15)	-0,18(0,08)
Transport	Lik/L	0,88	-0,77	1,17(0,13)	-0,88(0,14)	0,38	-1,31	1,18(0,08)	-0,07(0,11)	0,88	-1,24	0,89(0,04)	-	0,15	1,06	-0,11(0,82)	-0,13(0,38)
	Lik/Li	0,74	1,10	0,77(0,18)	-0,48(0,33)	0,82	0,03	0,82(0,20)	0,94(0,25)	0,78	0,10	0,45(0,20)	0,16(0,24)	0,97	0,03	0,93(0,14)	0,02(0,06)
Services	Lik/L	0,88	-0,18	0,87(0,50)	0,03(0,03)	0,93	-0,47	0,72(0,13)	0,14(0,15)	0,96	-0,34	0,73(0,23)	0,11(0,20)	0,68	-3,76	1,71(0,80)	0,61(0,26)
	Lik/Li	0,84	1,18	0,78(0,14)	-0,18(0,11)	0,83	1,08	0,68(0,20)	-0,11(0,20)	0,93	1,48	0,80(0,15)	-0,34(0,13)	0,94	-0,55	1,15(0,25)	0,06(0,08)

Table IX-8. MULTIPLE REGRESSION EQUATIONS LINKING THE EDUCATIONAL PROFILE IN SOME ECONOMIC SECTORS (Lik/Li)

TO {THE SECTORAL AND
THE EDUCATIONAL STRUCTURE OF THE LABOUR FORCE

log (Lik/Li) = log a + b log (Lk/L) + c log (Li/L)

ECONOMIC SECTORS	HIGHER LEVEL AND ABOVE (A)				COMPLETED SECONDARY SCHOOLING AND ABOVE (B)				MORE THAN EIGHT YEARS OF SCHOOLING (C)				EIGHT YEARS OF SCHOOLING AND LESS (D)			
	R	log a	b(σ b)	c(σ c)	R	log a	b(σ b)	c(σ c)	R	log a	b(σ b)	c(σ c)	R	log a	b(σ b)	c(σ c)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Manufacturing	0,90	-0,17	1,18(0,14)	-0,27(0,10)	0,89	0,58	1,27(0,14)	-0,83(0,21)	0,93	0,71	1,10(0,20)	-0,64(0,29)	0,92	0,16	0,87(0,16)	0,07(0,09)
Commerce	0,88	0,48	0,93(0,13)	-0,38(0,21)	0,88	0,78	1,08(0,20)	-0,68(0,30)	0,90	0,84	0,90(0,18)	-0,58(0,26)	0,96	-0,66	1,26(0,15)	0,11(0,09)
Transport	0,87	0,43	1,20(0,17)	-1,81(0,20)	0,87	0,38	1,23(0,08)	-1,88(0,17)	0,98	0,78	1,01(0,07)	-1,13(0,13)	0,99	-0,14	1,02(0,06)	0,16(0,04)
Services	0,88	1,31	0,84(0,16)	-0,78(0,27)	0,90	1,34	0,74(0,07)	-0,47(0,13)	0,97	1,38	0,63(0,06)	-0,47(0,11)	0,98	-0,55	1,13(0,14)	0,16(0,09)

Table IX-9. SIMPLE REGRESSION EQUATIONS LINKING THE EDUCATIONAL STRUCTURE (Lk/L) TO THE SECTORAL STRUCTURE OF THE LABOUR FORCE (Li/L)

log (Lk/L) = log a + b log (Li/L)

ECONOMIC SECTORS	HIGHER LEVEL AND ABOVE (A)				COMPLETED SECONDARY SCHOOLING AND ABOVE (B)				MORE THAN EIGHT YEARS OF SCHOOLING (C)				EIGHT YEARS OF SCHOOLING AND LESS (D)			
	n	R	log a	b(σ b)	n	R	log a	b(σ b)	n	R	log a	b(σ b)	n	R	log a	b(σ b)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Manufacturing	18	0,56*	-0,71	0,80(0,24)	13	0,72*	-0,22	0,97(0,30)	10	0,71*	-0,06	1,09(0,34)	10	-0,62	2,26	-0,35(0,15)
Commerce	18	0,55*	-0,21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Transport	18	0,63*	-0,15	0,94(0,28)	13	0,62	0,22	1,15(0,44)	10	0,76*	0,40	1,32(0,40)	10	-0,53	2,07	-0,35(0,20)
Services	18	0,48	-0,73	0,83(0,38)	13	0,36	0,18	0,63(0,49)	10	0,69	-0,34	1,20(0,44)	10	-0,56	2,34	-0,37(0,20)

- In commerce, redistribution will occur in favour of university graduates (+ 0.6%), followed by workers at "completed secondary level or above" (+ 0.4%) and then by those with more than eight years' schooling (+ 0.3%). Thus, in relation to the aggregate number in the last category, the total number with completed secondary education will increase, and, in relation to the latter, university graduates will in future be better represented.

- The trend is different in the transport sector, where the proportions represented by the various levels of education will remain roughly constant. The educational profile of this sector should therefore remain fairly stable. The same will apply to services, surprising as this may seem at first sight; it should not, however, be forgotten that the level of education in this sector is often fairly high, even in a developing country, and that the stability of the educational profile is accompanied by appreciable increases in absolute figures at all levels.

4. EDUCATIONAL AND SECTORAL STRUCTURE OF THE LABOUR FORCE

The purpose of this analysis is twofold; first, it will give some indication of collinearity between the explanatory variables in the previous equation; secondly, it will show whether certain levels of education may not be directly correlated with the sectoral structure of employment. It will be remembered that a similar line of thought was followed in Part Three, where the educational structure was directly compared with the occupational structure of the labour force. It may again be pointed out that the quality of the correlation coefficient interests us here much more than the elasticities.

The simple regression equation which should allow these assumptions to be tested is as follows:

$$\log (Lk/L) = \log a + b \log (Li/L)$$

The results are shown in Table IV-9.

Most of the correlation coefficients R lies between 0.60 and 0.75; it seems, therefore, rather difficult to make certain sectors correspond more specifically with certain levels of education. The negative correlations in the "eight years' schooling or less" column emphasize the major role of the economic sectors considered in absorbing qualified manpower. The position would certainly not have been the same with agriculture, for example.

However, the analysis does not yield any particularly new results. The elasticities which are equal or close to 1 are, however, noteworthy, as they should facilitate interpretation of the equations in section 3 (Table IV-8), where the sometimes fairly marked collinearity undoubtedly constitutes an obstacle.

XVIII

CONCLUSIONS

From this analysis of levels of education in the different economic sectors, conducted on the same lines as the analysis of the levels of education in the different occupational categories*, the following general conclusions emerge:

1. A single technological indicator usually suffices to "explain" a variable proportion of variance for the level of education concerned, provided that this is measured by Lik/L. Results are, however, especially poor for commerce and transport. In all sectors, non-monetary indicators give slightly better fits than labour productivity.

2. High correlations and more reliable regression coefficients are generally obtained when it is sought to "explain" Lik/L by taking the sectoral structure of employment Li/L; the improvement is particularly marked for commerce. There is, however, one exception - services - especially at the higher educational levels. There is obviously an important element of spurious correlation in this relationship. However, this type of equation provides interesting information about the redistribution or deployment of school-leavers and graduates within each economic sector when the relative weight of this sector, in terms of total employment, changes. This is, therefore, analogous to the analysis carried out with occupation/education relationships presented in Part Three, Chapter XI.

3. As in the case of occupational categories, levels of education in the different economic sectors - measured by Lik/Li or Lik/L - show particularly close correlation with the available supply of qualified manpower at different levels (Lk/L), whatever economic sector is considered. This type of equation also provides some idea of the distribution through the economic sectors of qualified manpower at each educational level, by comparing the various elasticities of (Lik/L) with respect to (Lk/L).

4. When educational levels in the different economic sectors are tested both with technological indicators (n) and the educational structure of the labour force (Lk/L), the latter accounts for a major proportion of the explained variance in Lik/L. Once again, this suggests that the development of the educational system results in educational supply

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* See Part Three.

effects which are, to a certain extent, more influential than the technological indicators in the shaping of educational profiles (or levels) of economic sectors.

5. Lastly, when L_{ik}/L_i is tested simultaneously for the sectoral structure of employment (L_i/L) and the educational structure of the labour force (L_k/L), it is again the latter which accounts for the major part of the variance in L_{ik}/L_i. Note that the elasticities for L_{ik}/L_i in relation to L_i/L are always negative when L_k/L is maintained constant.

Part Five

OCCUPATIONAL CATEGORY AND LEVEL OF EDUCATION
SOME SUPPLEMENTARY ANALYSES

XIX

INTRODUCTION

1. OBJECT OF THE STUDY

Since educational planning was invented, it has always been recognized that the step leading from occupational categories to levels of education is the weakest point in the whole process of quantifying the economic aims of education by long-term manpower forecasting; both the detractors and the defenders of the method agree about this. It may not, therefore, be a waste of time to revert briefly to this occupation/education link, which is ultimately the specific point where the educational system and the labour market meet.

When all is said and done, the great dilemma besetting the relation between occupational categories and levels of education may be reduced to a discussion of the "specialization" or "mobility" of the products of the educational system. The planners advocating "specialization" believe that they can fairly accurately forecast the requirements in each occupational category, and that their only problem is to find the level of education best associated with each category.

Contrariwise, the advocates of "mobility" are drawn from among those who are sceptical as to the possibility of reliable manpower forecasting. Their position might be summed up as follows: as accurate forecasting is impossible, it only remains to ensure that each level of education allows the most varied possible choice of occupations. Recent developments in the educational systems of most countries in the world supply them with an additional argument; as an increasingly high level of education is attained by increasingly broad layers of the population, there is no need for forecasting; on the contrary, the main thing is to ensure general mobility, to enable each individual to exercise the maximum freedom.

We have, of course, shown the two aspects of the problem in a caricatural light. The champions of "specialization" know full well that to each occupational category corresponds a relatively broad educational profile, and that even (or rather especially) in the advanced countries, there should be no hesitation in allowing every opportunity for social betterment, which would be reflected in a large share in the profile for the self-taught. * Similarly, there are few advocates of "mobility" who

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* In such countries as Britain or France, it is estimated that 30 to 40% of the highly qualified scientific personnel in certain industries have no university degree.

do not accept forecasting up to a point, especially in the less-industrialized countries, where occupational mobility can only operate within strict and narrow limits.

This study certainly has no pretentions to solve the problem, even by a "synthesis" conciliatory to both sides. All we want to do here is to consider, in the light of our present knowledge, how the occupational category level of education relationship tends to change over time. In other words, does the educational profile of a given occupational category tend to reach its peak with *one* specific level of education, the *association* between the occupation and the level of education thus tending to become a hard-and-fast relationship ? Or, on the contrary, does the educational profile tend to flatten out, with each level of education contributing an equivalent proportion of the numbers in the occupation concerned, the *association* between them tending to become looser ?

It can well be imagined that it is not easy to give a *universal* answer to this question; commonsense suggests that the replies would be contradictory. It may seem "natural" to require a university degree for all "professional and technical workers" (major group 0), though a large proportion of them do not possess this level of education, even in the most advanced countries. Similarly, it might be supposed that the rise in the level of education of "manual workers and craftsmen" was more particularly due to the generalization of compulsory schooling; in actual fact, the emergence of an elite with completed secondary education in this group, even in countries where such education is nowhere near being the general rule for the age-group concerned, negates this assumption.

Furthermore, our regression analyses in Parts Three and Four provide only part-answers to this problem of association between occupational categories and levels of education; the trend followed by each level of education was, in fact, studied for each occupational category *in turn*. The interest of the present analysis, on the other hand, is that it gives some indication of the trend of the occupational category/level of education association *as a whole*, allowing for the interaction of the different levels of education* and of the different occupational categories.** Is the link between occupation and level of education really tending to tighten or to loosen ? If the former, the planner's task would obviously be simplified; if the latter, he would have to take this into account in his forecasting.

2. MEASURES OF ASSOCIATION USED

A great variety of measures of association exists for use in cross-classifications presented in matrix form. Very few of them are satisfactory, however, and it is essential to choose the ones to be used in accordance with the aim in view and its inherent statistical constraints. In our case, a twofold problem arises, as the occupation/education association has first to be derived from complete *matrices*, and then from simple *vectors* representing the educational profile of a given occupation.

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* Chapter XXI.

** Chapter XX.

i) Measures of association for matrices

The best known have been exhaustively described by L. A. Goodman and W. H. Kruskal in a series of articles often quoted and widely used.[*] We have adopted two of these measures, lambda (λ) and gamma (γ), which are fairly similar as regards the way in which they can be used, although very different in conception.

As far as their common features are concerned, it may first be noted that "λ" and "γ" are universal measures of association, based on a stochastic forecasting model. Their advantage is to reduce a matrix to a single synthetic indicator, thus facilitating inter-matrix comparisons. These two measures may range between 0 and 1; the association between occupational categories and levels of education will be strong when λ or γ approaches unity, and weak when λ or γ approaches 0.[**] The value of these measures varies considerably, as we shall see, according to the classifications used, and we shall not, therefore, try to interpret any one measure of association (for example, does 0,254 signify a clear, fair or vague association ?), although this is theoretically possible. On the contrary, our analyses will be based on the relative values of γ and λ for perfectly comparable matrices, which will give us some idea of the evolution over time or space of the existing association between occupational categories and levels of education. Whenever possible, we shall establish a relationship between the various measures of association (each representing a matrix) and an economic variable of the labour productivity type (value added per man-year). No significance test is unfortunately available for either of these two measures; in other words, if different values are found for λ or γ with different matrices, it will be impossible to say from what point the variation shown becomes significant. Caution should, therefore, be exercised in interpreting the results.

The chief differences between λ and γ are as follows: γ is a measure of association applying only to ordered polytomies; its use will, therefore, depend on the possibility of ordering (a) the levels of education, which raises few problems, and (b) the occupational categories, which is already more difficult. On the other hand, λ required no ordering.

For γ , the two polytomies are symmetrical; for λ, on the other hand, they are asymmetrical, one of the classifications "preceding" the other. As we are studying the occupation/education association from the aspect of the educational profile of the different occupational categories, we shall consider that the occupational precedes the educational classification.[***]

Lastly, the calculation of λ itself, based on the maximum frequencies of the workers in each category in a given level of education, is extremely simple and can be worked out by hand. The calculation of γ, on the other hand, based on the contingent probabilities, takes much longer, and requires an electronic computer.

[*] "Measures of Associations for Cross-classifications" by Leo A. Goodman and William H. Kruskal, Journal of the American Statistical Association, December 1954, March 1959 and June 1963.

[**] In actual fact, γ may range from - 1 to + 1, but the negative values are of no interest in this particular case.

[***] It may be noted in passing that the occupation/education link could easily be considered from the opposite angle : that of the occupational choice of qualified manpower; in this case, the educational classification (independent variable) precedes the occupational classification (dependent variable).

ii) Inter-vector comparison

As noted above, λ and γ are measures applying to complete matrices. The information they yield is therefore very difficult to interpret; in particular, it is extremely hard to give a visual representation of what occurs when λ and γ vary; a graphic representation is impossible.

We shall, therefore, confine our efforts, in this case, to converting a vector (here the educational profile of a given occupational category) into a manageable measure which may range from a minimum (indicating that the total numbers in the group are clustered on one level of education) up to a maximum (indicating that the numbers are equally distributed over all levels of education). The information theory relating to the probabilies of occurrences* seems to provide a sound answer. The quantity H "translating" the educational profile of a given vector is called the entropy; this may vary from a maximum ($H = \log n$), translating an equivalent representation of the n levels of education in the occupational group, to a minimum ($H = 0$), indicating a perfect "association" between the occupational group concerned and a given level of education.

This analysis by vectors will therefore complete the analysis made at matrix level; when the occupation/education association rises or falls within the matrices, it is obviously interesting to find out to what extent the different occupational categories are responsible for the variation.

Chapter XX will, therefore, be devoted to the measures of association at matrix level; an analysis of certain educational profile vectors will be found in Chapter XXI.

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* See Annex E: a note on the information theory. For more details, see Information Theory and Economic Analysis, by H. Theil, North Holland Publishing Company, Amsterdam, 1967.

XX

MEASURES OF ASSOCIATION AT MATRIX LEVEL

As might be expected, the application of this measure requires the most highly detailed matrices; that is why international comparisons similar to those in Parts Three and Four of this study are impossible. The international classification of education which we have been able to establish for twenty-five countries remains too rudimentary for any measures of association; and the fact that the levels of education are cumulatively defined would be an additional obstacle.

We shall, therefore, confine ourselves to a few applications in the countries whose occupational category/level of education matrices have been concentrated over time by the introduction of the age-group dimension, or spatially by the introduction of the economic sectors.

Before commenting on them, it may be pointed out that λ has already been applied to Japan* to measure the variation in the occupation/education association in that country between 1950 and 1960, and that it is applicable to all countries with time series of matrices: United States (1940-1960), France (1954-1962), with certain reservations.

As regards γ, already used for the United States**, France*** and Uruguay****, this may be employed whenever the occupational classification has been so compiled that the various categories can be ordered.

1. APPLICATION OF LAMBDA "λ"

There was no difficulty in applying this measure to Canada and Argentina. Both countries keep treble-entry tables cross-classifying the occupational groups, levels of education and age-groups. *****

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* In A Technical Evaluation of the First Stage of the Mediterranean Regional Project, OECD, Paris, 1967, pages 159 and seq.

** "Trends in Education in relation to the Occupational Structure", by J.K. Folger and C. Nam, in Sociology of Education, Fall 1964, Volume 38.

*** "Fréquentation scolaire et composition de l'emploi", by L. Tanguy, in Cahiers d'études des sociétés industrielles et de l'automation, No. 8, 1966-67, CNRS.

**** "Education, Occupation and Development", by A. Solari, N. Campiglia and S. Prates, in the International Social Science Journal, No. 3, 1967, UNESCO.

***** The Contribution of Education to Economic Growth, by G.W. Bertram, prepared for the Economic Council of Canada, Staff Study No. 12, June 1966: see Appendix, Table A-2. Education Human Resources, and Development in Argentina, OECD, Paris 1967: see Table III-26.

Argentina also keeps treble-entry tables, cross-classifying the occupational groups, levels of education and economic sectors. *

The numerical values of λ, calculated by age groups, in Canada and Argentina, are shown in Table V-1. Only the "25 years and over" age-groups were considered, to avoid any distortions due to the fact that a proportion of younger people with a high standard of education have not yet entered the labour force. The calculations in this table were made with absolute frequencies.

Table V-1. TREND OF "λ" AS A FUNCTION OF THE AGE-GROUP: ABSOLUTE FREQUENCIES

AGE-GROUPS	25-34	35-44	45-54	55-64	64 OR OVER
CANADA: 1961					
13 occupational categories[1] 6 levels of education[2]	0.162	0.137	0.094	0.044	0.054

AGE-GROUPS	25-29	30-34	35-44	45 OR OVER
ARGENTINA: 1960				
11 major occupational groups[3] 5 levels of education[4]	0.079	0.060	0.053	0.017
17 occupational categories[5] 5 levels of education[4]	0.126	0.134	0.128	0.078
7 occupational sub-groups[6] 6 levels of education[4]	0.344	0.446	0.456	0.458

1. The classification adopted is the ISCO, with a few slight variations: major group 4 (Farmers, fishermen ...) is here broken down into three sub-groups; and one more group has been added: "Unspecified occupation".
2. Primary school: (0 - 4 years), (5 - 8 years).
   Secondary school: (1 - 3 years), (4 years).
   Some years at University.
   University Degree.
3. The same as in the ISCO, with Major Group 7/8 subdivided into "Manual workers and Craftsmen" and "Unskilled workers and day labourers".
4. No education, Primary, Secondary, Higher, University.
5. Categories indicated in notes (3) and (6).
6. Minor groups of the ISCO, Major Group 0, aggregated as follows:
   - Scientific and technical Personnel: minor groups 00, 01, 02 and 0X.
   - Physicians, surgeons and dentists: 03.
   - Para-medical workers: 04, 05.
   - Others: 08, 0Y.
   - Teachers: 06.
   - Artists, writers: 09.
   - Clergy: 07.

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* See previous note: "Methodological problems and statistical sources", Annex K.

The findings for Canada yield the clearest conclusion: except for the "65 years and over" group, the occupational category/level of education association diminishes with age. It thus rises as time goes on, if it is agreed that the stratification by age-groups provides an acceptable representation of the trend over time.

The same conclusion may be reached for Argentina, while noting that the values of λ are extremely small. The reason lies in the method of calculating λ: it approaches 0 when most of the maximum frequencies are in the same column - here the primary level of education. *

In comparing the values of λ obtained with 11 and 17 occupational groups (the latter obtained by disaggregating major group 0, which is the best educated), it can be seen that those values rise significantly as the classification becomes more detailed. At the same time, the trend of λ is less clear: the association remains practically stable up to the age of 45.

If the calculation is repeated with the matrices reduced to seven sub-groups of major group 0, the values of λ indicate a much better association between the sub-groups and the level of education. The trend, however, is far from clear: the association appears stable for the over 35s, but losser for the younger age-groups.

When λ is calculated with absolute frequencies, the values obtained have the disadvantage of being the resultant of variations in the association itself and of changes in the occupational structure depending on the age group. To abstract the latter, the calculations were re-made with relative frequencies**; the main results will be found in Table V-2.

Table V-2. ARGENTINA: TREND OF "λ" AS A FUNCTION OF THE AGE-GROUP: RELATIVE FREQUENCIES

	25-29	30-34	35-44	45 AND OVER
11 major occupational groups 5 levels of education	0.094	0.066	0.067	0.026
17 occupational categories 5 levels of education	0.340	0.358	0.380	0.323
7 occupational sub-groups 5 levels of education	0.405	0.447	0.479	0.415

NOTES: See notes to Table V-1.

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* We are then dealing with an instance of an indeterminate λ, not with a nil occupation/education association.

** I.e., with percentages, the total numbers in each occupational category being represented by 100.

The association diminishes with age - i.e., rises over time - for the eleven major occupational groups. The conclusion here is the same as before. On the other hand, there is a distinct increase in the association as the age-group rises (except for the over 45's) with a more specific occupational classification: it thus diminishes over time.

Lastly, the spatial trend of association has been studied for Argentina, using the treble-entry tables - occupational categories, levels of education and economic sectors - available for that country. Here again, the calculations were made, first, with absolute frequencies and, next, with relative frequencies: Table V-3. As can be seen, the values of λ based on the latter are higher than those based on the former; but it is disquieting to note that the two *trends* seem to be independent: R = -0.46 (Spearman's coefficient). Both series of measures of association were also correlated with labour productivity (Spearman's coefficient):

Correlation between X/L and λ (absolute frequencies): $R = 0.44$

Correlation between X/L and λ (relative frequencies): $R = 0.35$

Lastly, column 4 in Table V-3 gives another series for λ, leaving out of the calculation the occupational category "manual workers and craftsmen", which is far and away the largest numerically speaking, because we thought that the weight of this category might introduce some distortion: its maximum frequency is invariably found at "no education and uncompleted primary" level. The values in column 4 are indeed very different from those in column 1.

The general impression left by all these measurements is that it would be very rash to draw any conclusions as to the trend over time or space of the occupational categories/levels of education association. The only certainty is that the association rises, on the one hand, as the classifications considered become more detailed, and, on the other hand, when relative frequencies are used instead of absolute frequencies. The latter fact leaves no doubt that the variations in the occupational *distribution* from one matrix to another have a great influence on the degree of occupation/education association.

2. APPLICATION OF GAMMA "γ"

Of all the statistical data at our disposal, the 1961 Peruvian census data certainly lend themselves best to a γ application. It was found possible to establish, with a 10% sample of this census, an occupational categories/levels of education matrix for each of the 17 branches of the economy.* Moreover, it was fairly easy to put in order the two classifications, which is one condition of application of γ, as already pointed out. The educational classification adopted for that country sub-divides each level of education into cycles; it was, therefore, quite easy to draw up nine graduated levels of education, it being agreed that the level of instruction 6 (engineering science) is of "higher" quality than the instruction given in the other faculties: level 5.**

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* See *Desarrollo economico y social, recursos humanos y educacion*, National Planning Institute: OECD, Lima, June 1966: Annexe III-V; and in French, *Ressources humaines, éducation et développement économique au Pérou*, OECD, Paris, 1967, pages 397 and seq.

** See details of the classifications in the notes to Table V-4.

Table V-3. ARGENTINA: TREND OF "λ" AS A FUNCTION OF INDUSTRIAL BRANCHES

INDUSTRIAL BRANCHES	ABSOLUTE FREQUENCIES 1	RELATIVE FREQUENCIES 2	X/L 3	ABSOLUTE FREQUENCIES 4
Food, beverage and tobacco industries	0.071	0.146	208	0.196
Textiles	0.054	0.132	174	0.097
Footwear and other wearing apparel	0.012	0.152	- a)	0.055
Wood and cork industries, printing	0.038	0.183	-	0.152
Paper and paper products ..	0.035	0.192	132	0.124
Chemical products, petroleum and coal products	0.014	0.184	326	0.181
Basic metal industries	0.065	0.195	110	0.217
Metal products, machinery and electrical equipment .	0.033	0.153	219	0.163
Transport equipment	0.027	0.142	166	0.184
Electricity, gas and water .	0.010	0.238	212	0.289
Construction	0.035	0.132	99	0.114
Transport and communications	0.149	0.097	108	0.167

NOTES: Columns 1 and 2:

Occupational categories: 8 drawn from the ISCO.

- Scientific and techical personnel: 00, 01, 02, 0X.
- Artists and clergy, etc.: 07, 09.
- Other professional workers: other sub-groups of Major Group 0.
- Administrative and managerial workers.
- Clerical workers.
- Sales workers.
- Craftsmen and manual workers.
- Other workers.

Levels of education: 6.

- No education and uncompleted primary.
- Completed primary.
- General and technical secondary: uncompleted.
- General and technical secondary: completed.
- Post-secondary and university: uncompleted.
- University degree.

Column 3:

Value added per man-year: 103 1960 pesos.

Column 4:

Occupational categories: 7. The same as in column 1, excluding craftsmen and manual workers.

Levels of education: 6. Same in column 1.

a) Owing to the incompatibility of the employment and value added statistics, it was not feasible to calculate X/L for these two branches; it was, however, possible to determine their ranking in relation to productivity in the other branches: 7th and 5th respectively.

It was more difficult to order the occupational classification; somewhat varied criteria were applied in this case, ranging from social prestige to average wage level, without overlooking the average level of qualification. The ranking of some of the 13 occupational groups could, of course, invariably be contested, especially at the top of the scale: should military personnel take presidence over scientific staff, should clergy come below technicians ? In the case which concerns us, these are minor changes which would do nothing to modify the tenor of our conclusions as to the trend of γ as a function of the economic sectors.

This being granted, γ was calculated for each of the 17 economic sectors, using matrices successively based on:

- total employment in the sector;
- male workers in the sector, to eliminate any distortion arising from differences in qualification between men and women workers;
- urban employment in the sector, to make allowance for census errors, which are often larger in rural areas than in towns.

Lastly, another series of γ was calculated with matrices cross-classifying the same levels of education as before, with only the eleven occupational sub-groups included in categories 0, 1 and 2, (professional and technical workers) of the previous classification. *

As in the case of λ, the calculations were based, first, on absolute frequencies, then, on relative frequencies, to eliminate variations in the association due to changes in occupational structure.

The values of γ for these eight series of 17 sectors each are shown in Table V-4.

We may begin with a few general remarks.

- Leaving aside agriculture, for which γ is close to 0, the occupation/level of education association varies widely according to the sector; it is lowest for the metal-working industries (0.200), and highest for "other services" (0.628) (column 1). The fact that female or rural labour is excluded does not change the results (columns 2 and 3).
- More generally, there is a good rank correlation between columns 1, 2 and 3. Only for the textile sector, which shows a high association ($\gamma = 0.586$, 3rd rank) with its total labour force, does the association decline sharply when it is calculated with urban employment ($\gamma = 0.329$, 14th rank) or with male workers ($\gamma = 0.377$, 14th rank). For this sector, then, the particularly large force of women workers (52% of the total), and the manpower working in rural areas (38% of the total), usually on a craft industry basis, help to send up the occupation/education association very substantially.
- Attention should also be drawn to the high values of γ in column 4; once again, the association rises sharply as the occupational classification becomes more detailed.

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* See details of the classifications in the notes to Table V-4.

Table V-4. PERU: TREND OF "γ" AS A FUNCTION OF THE ECONOMIC SECTORS

ECONOMIC SECTORS		ABSOLUTE FREQUENCIES				RELATIVE FREQUENCIES			
		TOTAL ACTIVE POPULATION	ACTIVE URBAN POPULATION	ACTIVE MALE POPULATION	MAJOR GROUP 0 (ISCO)	TOTAL ACTIVE POPULATION	ACTIVE URBAN POPULATION	ACTIVE MALE POPULATION	MAJOR GROUP 0 (ISCO)
	CODE No.	1	2	3	4	5	6	7	8
Agriculture	01	0.013	0.081	0.027	0.614	0.561	0.596	0.652	0.509
Fishing	02	0.423	0.469	0.403	0.672	0.505	0.515	0.483	0.504
Mining and quarrying	03	0.527	0.494	0.515	0.685	0.472	0.463	0.471	0.664
Food, beverage and tobacco industries	04	0.308	0.302	0.315	0.784	0.611	0.608	0.593	0.619
Manufacture of textiles	05	0.586	0.329	0.377	0.745	0.734	0.519	0.728	0.534
Manufacture of chemicals	06	0.496	0.503	0.511	0.743	0.445	0.442	0.444	0.671
Metal industries and manufacture of metal products	07	0.201	0.218	0.190	0.864	0.444	0.441	0.442	0.798
Other manufacturing industries	08	0.436	0.438	0.430	0.178	0.427	0.410	0.428	0.278
Construction	09	0.398	0.394	0.391	0.926	0.593	0.589	0.593	0.780
Electricity, gas and water	10	0.576	0.602	0.580	0.732	0.526	0.528	0.534	0.570
Transport and communications	11	0.512	0.505	0.501	0.517	0.535	0.496	0.536	0.644
Commerce	12	0.523	0.520	0.489	0.817	0.449	0.444	0.462	0.757
Banking and insurance	13	0.602	0.585	0.611	0.880	0.523	0.521	0.538	0.827
Government services	14	0.404	0.364	0.379	0.673	0.533	0.529	0.526	0.616
Public and private education	15	0.541	0.589	0.643	0.227	0.429	0.429	0.469	0.526
Other services	16	0.628	0.612	0.650	0.569	0.479	0.509	0.514	0.537
Unspecified activities	17	0.425	0.419	0.407	0.568	0.499	0.489	0.514	0.449

NOTES:

Columns 1, 2, 3 and 5, 6, 7.

Occupational categories: 13 in the following order:

62	Family workers in agriculture
63	Unskilled workers
7	Unemployed, persons seeking work
61	Semi-skilled workers
60	Skilled workers
5	Sales workers
4	Clerical workers
3	Administrators, executives and managerial workers
2	Technicians
8	Members of the armed forces
9	Clergy and members of religious orders
1	Non-scientific professional workers
0	Highly-qualified scientific and technical personnel

Levels of education: 9 in the following order:

00	Illiterate
10	Up to 4 years' primary schooling
11	4 to 6 years' primary schooling
20/30	Secondary level, first cycle: general and technical
21/31	Secondary level, higher cycle: general and technical
7/9	Post-secondary education
4	Teacher training schools
5	University level
6	University level: engineering sciences

Columns 4 and 8.

Occupational categories: 11 in the following order:

27-8-9	Other technicians
24-5-6	Para-medical workers
21/23	Laboratory technicians, draftsmen
20/22	Transport technicians, pilots
18	Professional artists
15/17	Social science specialists, jurists
10-14	Teachers
06-09	Veterinaries, doctors, dentists
03-05	Other engineers
00-02	Agronomists, civil engineers and mining engineers

Levels of education: Same as above.

- Taking now the values of γ calculated from relative frequencies, we find here again a good rank correlation between the series for the total labour force, urban workers and male workers.
- This is not the case if the series obtained with relative frequencies are compared with those obtained with absolute frequencies: R (Spearman) = -0.22 with the total labour force (columns 1 and 5). As in the case of λ, the variations in the association are thus very different according to whether the variations in occupational structure are or are not taken into account.
- The above conclusion does not hold good for the sub-groups of major group 0; the two series of γ in columns 4 and 8 evolve on practically the same lines: R (Spearman) = 0.79, whereas the composition of major group 0 varies widely from sector to sector (example: no teachers in mining; teachers representing nearly 100% of the numbers in the education sector).

An attempt was also made to link the measures of association with a few economic variables characteristic of each sector: sectoral employment (total, urban or male), gross value added in 1960, sectoral labour productivity, the proportion of "white collar" workers and "professional and technical workers" in sectoral employment. These variables are shown in Table V-5.

Using Spearman's correlation coefficient, we arrived at the following conclusions.

1. There is no significant relationship between the closeness of the occupation/education association* and the size of the sector, as measured by total, urban or male employment.
2. The value added by sector, and sectoral productivity, are also independent of the occupation/education association. *
3. On the other hand, the association does show a significant correlation with the percentage of "white collar" workers in sectoral employment, provided that it is calculated on the basis of absolute frequencies:

   R = 0.70 (association calculated with urban employment)

   R = 0.68 (association calculated with male employment)

   R = 0.48** (association calculated with total employment).

   Very similar results were obtained with the percentage of "professional and technical workers" in total employment.

   When the association is calculated on the basis of the relative frequencies, none of the above correlation coefficients is significant.
4. Lastly, sectoral productivity shows a significant correlation with the occupation/education association, calculated for the sub-groups of major group 0: R = 0.61 (relative frequency). Leaving aside the fishing and construction sectors, which show some special features in Peru***, we obtain R = 0.87.

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* Whether calculated with absolute or relative frequencies.

** R = 0.67 if the textiles sector is eliminated: see above.

*** The members of major group 0 working in the fishing sector numbered 260 in 1960, nearly all belonging to the Pilot's Corporation. As for the construction sector, the low productivity per head is notorious.

Table V-5. PERU: SOME SECTORAL VARIABLES

ECONOMIC SECTORS	CODE	TOTAL ACTIVE POPULATION ('000) 1	ACTIVE URBAN POPULATION ('000) 2	MALE ACTIVE POPULATION ('000) 3	GROSS VALUE ADDED (10^6 SOLS) 4	VALUE ADDED PER PERSON EMPLOYED (10^3 SOLS) 5	PROPORTION OF "WHITE-COLLAR" WORKERS IN SECTORAL EMPLOYMENT:% 6	PROPORTION OF PROFESSIONAL WORKERS IN SECTORAL EMPLOYMENT:% 7
Agriculture	01	1,534.0	270.0	1,317.6	12,313.2	8.0	0.7	0.12
Fishing	02	21.1	16.0	20.8	1,010.6	47.9	3.5	1.23
Mining and quarrying	03	66.3	29.5	64.7	5,221.8	78.8	14.8	3.33
Food, beverage and tobacco industries	04	52.2	444.4	45.3	4,006.6	76.8	15.4	1.25
Manufacture of textiles	05	191.8	118.9	92.1	2,141.5	11.2	2.8	0.29
Manufacture of chemicals	06	14.4	12.7	11.7	1,416.2	98.4	35.3	10.94
Metal industries and manufacture of metal products	07	55.7	50.3	54.8	1,934.3	34.7	5.0	0.77
Other manufacturing industries	08	96.8	78.3	91.1	2,014.9	20.8	9.8	1.75
Construction	09	104.7	86.2	103.6	2,086.2	19.9	5.6	2.29
Electricity, gas and water	10	8.6	7.6	8.2	235.3	27.4	22.9	2.99
Transport and communications	11	93.9	84.5	89.4	3,193.0	34.0	15.5	1.85
Commerce	12	263.0	224.1	186.8	10,449.2	39.7	95.2	1.53
Banking and insurance	13	18.8	18.4	15.6	2,214.5	117.8	80.5	5.79
Government services	14	115.6	106.5	106.7	3,150.0	27.2	29.0	6.52
Public and private education	15	65.9	55.8	27.6	1,500.0	22.8	90.8	82.52
Other services	16	295.1	257.5	107.7	3,250.1	10.9	18.8	9.90
Unspecified activities	17	123.0	92.8	98.0	-	-	16.4	1.90

SOURCE: Ressources humaines, Education et Développement économique au Pérou, OECD, Paris, 1967.

To sum up, it does seem that the size of the non-manual occupational categories in each sector has a decisive influence on the intensity of the occupation/education association. More specifically, only the association between the sub-groups of "professional and technical workers" and their level of education has any relationship with *per capita* productivity.

XXI

INTER-VECTOR COMPARISONS

As stated in our introductory paragraph, we shall use information theory to compare the educational profile vectors of each occupational category.

The conditions of application of the entropy are very simple; let us briefly recall them:

- the educational classification need not be ordered, and the levels of education must be independent of each other;
- the sum of the respective probabilities that each member of a given occupational group will have a given level of education must be equal to 1: the profile vectors will therefore have to be shown in percentage form, the total numbers in each occupation being equal to 100;
- the method of calculation of the entropy (H) makes it range from 0 to log n (n being the number of educational levels considered). When H tends towards 0, this means that the numbers in the whole occupational group tend to be concentrated in one level of education; when H tends towards log n, there is equi-probability, i.e. the numbers are equally divided among the different levels of education.

The country which lends itself most conveniently to this type of application is undoubtedly Argentina, which has treble-entry matrices for occupational categories/levels of education economic sectors. The educational classification adopted for this country is, in fact, highly detailed: 16 levels for each of the 20 economic sectors. *

The educational profile of major group 0 in each sector was the first chosen for the calculation of the entropy. The latter was then correlated with the sectoral productivity, with unequal results according to the number of sectors considered, as can be seen from the following table:

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* For the purposes of this section, we shall thus obtain $0 < H < \log 16$, or $0 < H < 4$. These are binary logarithms. The values of H will be found on the corresponding graphs.

Table V-6. INTER-SECTORAL PRODUCTIVITY-ENTROPY CORRELATIONS

(Major Group 0 with 16 levels of education)

12 economic sectors[1]	R_1 (Spearman) = -0.08
20 economic sectors[2]	R_2 " = 0.15
18 economic sectors[3]	R_3 " = 0.54
9 branches of industry[4]	R_4 " = 0.77
11 branches of industry[5]	R_5 " = 0.80

1. The manufacturing industries being grouped in a single sector.
2. The manufacturing industries being broken down into nine branches of industry.
3. Same as in note 2, less government services and real estate.
4. The same as those mentioned in note 2.
5. The same as in note 4, plus construction and transport.

A rapid glance at the above table shows a positive correlation between entropy and productivity, provided that relatively homogeneous sectors are being compared, as is the case for R_4 and R_5.* In other words, the higher the productivity, the higher the entropy, so that the educational profile of major group 0 may well be flat (tending towards equi-probability).

This phenomenon was graphically confirmed for two branches of industry: the chemical industries and the basic metal industries. Graph V-1 shows that the educational profile of major group 0 in metal industries features two very pronounced peaks at "completed technical secondary" and "university science degree" levels, which account between them for nearly 60% of the numbers in the group. In the chemical sector, on the other hand, 60% of major group 0 are distributed among four peaks, representing "completed primary" (9.1%), "completed technical secondary" (16.8%), "completed university science courses" (23.2%) and "completed university medical courses" (14.1%), giving a higher entropy. But labour productivity in the chemical sector is nearly three times as high as in metals. This seems to indicate that there is a fairly marked link between high productivity and the general standard of education in major group 0; conversely, relatively low productivity goes with congruence between the numbers in this group and two very specific levels of education.

It is, however, possible that the positive correlation observed between entropy and productivity in major group 0 is the resultant of a negative correlation for technical occupations** more than

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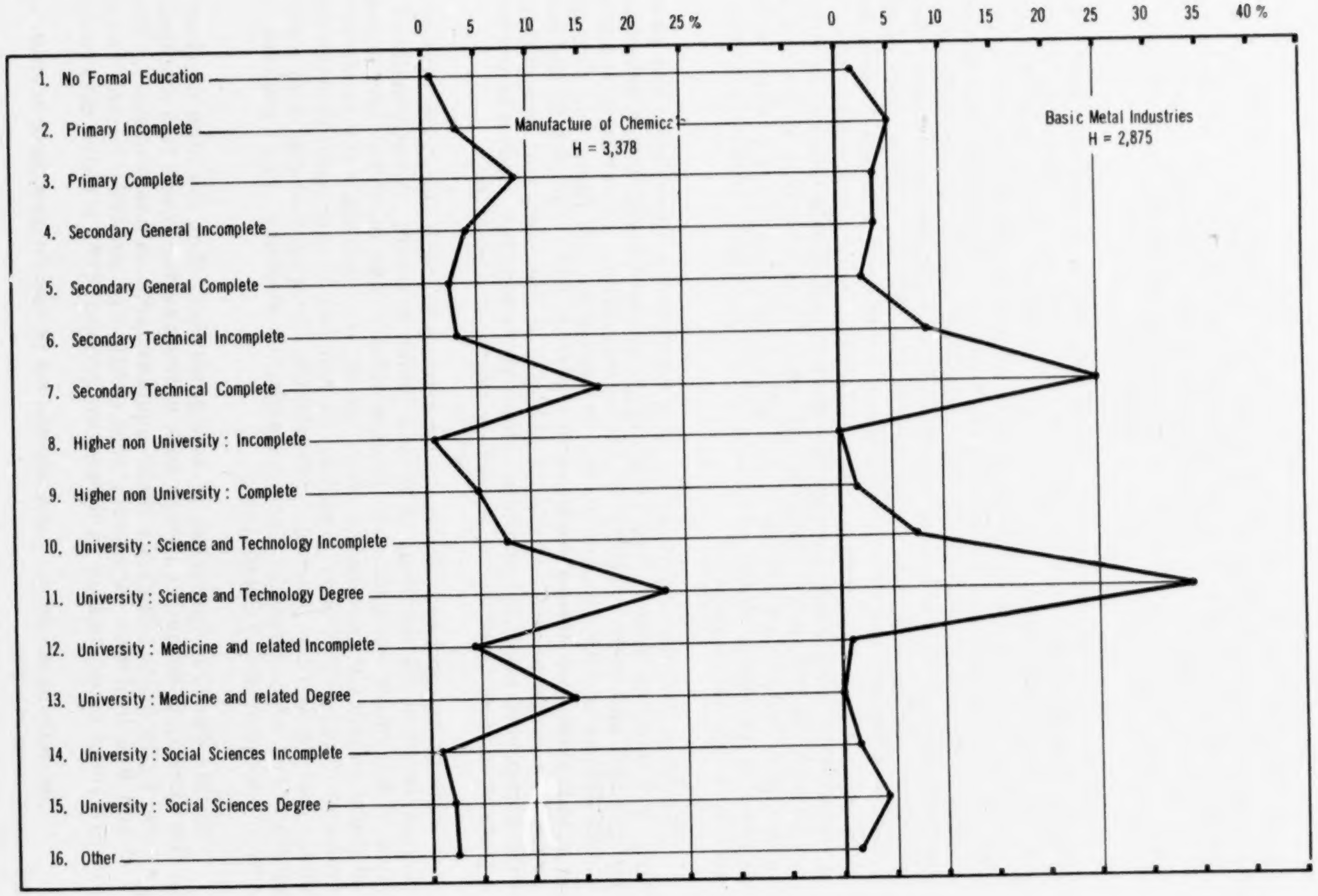
* It can also be seen that the simple fact of subtracting two sectors (government and real estate) in which labour productivity, as here calculated, is not very meaningful, suffices to raise the correlation coefficient sharply.

** Commonsense would suggest that these "must" have the appropriate level of education, i.e., a low entropy.

Graph V.1

EDUCATIONAL PROFILE OF MAJOR GROUP 0 IN TWO INDUSTRIAL BRANCHES



compensated for by a positive correlation for non-technical occupations. *

Major group 0 was therefore sub-divided into its two main components, "non-scientific professional workers" (Graph V-2) and "scientific and technical workers" (Graph V-3). It was then found that the converse is also true: it is mainly the latter sub-group which is responsible for the entropy for major group 0 in the chemical industries being higher than in basic metals**, although non-scientific professional workers also contribute to this result. ***

The above examples might, however, seem to indicate that the entropy/productivity link is stricter and, above all, easier to interpret than is in fact the case. By way of an "antidote" let us consider Graph V-4 describing the educational profile of major group 0 in two sectors with roughly equivalent levels of productivity; the textile industries and transport equipment for which the entropies are distinctly different. In the first sector, 55 to 60% of the numbers in the group are distributed over four peaks, compared with 70% in the second. More specifically, Graph V-4 shows that, in the "modern" branch of transport equipment, emphasis is laid on scientific education (secondary and university level), to the almost total exclusion of all other types of education; on the other hand, in the more "traditional" branch of textiles, there are almost equal numbers of science and arts graduates among those with university degrees; there is also a large contingent in major group 0 with primary level only.

We thus seem to be arriving at a conclusion opposite to the previous one: the modern sector demonstrates a certain congruance between major group 0 and very specific levels of education, whereas in the traditional sector widely diverse levels of education are found for this group. In actual fact, the diversification in the first case was due to the emergence of a large section of major group 0 in the chemical industries with completed medical studies, whereas in textiles, there is probably a persistence of traditional levels or types of education.

This being granted, there is no reason to limit the productivity comparisons to the entropy in major group 0 alone; the educational profiles of the other occupational groups should also be taken into account, as their respective entropies can confirm or invalidate the positive correlation found with major group 0. Reverting to our earlier example of basic metals and the chemical industries, Graphs V-5 and V-6 were plotted for "administrators and managerial workers" and "manual workers and craftsmen" respectively.

In this specific instance, it was confirmed that the high productivity in the chemical industries goes with entropies for these two occupational groups, being higher than for their counterparts in basic metals. Graphs V-5 and V-6 indicate, however, that caution is needed; having regard to the low level of education in these two groups****, a more diversified

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* The idea being that the occupation/education link for these categories would be looser, i.e., the entropy would be higher.

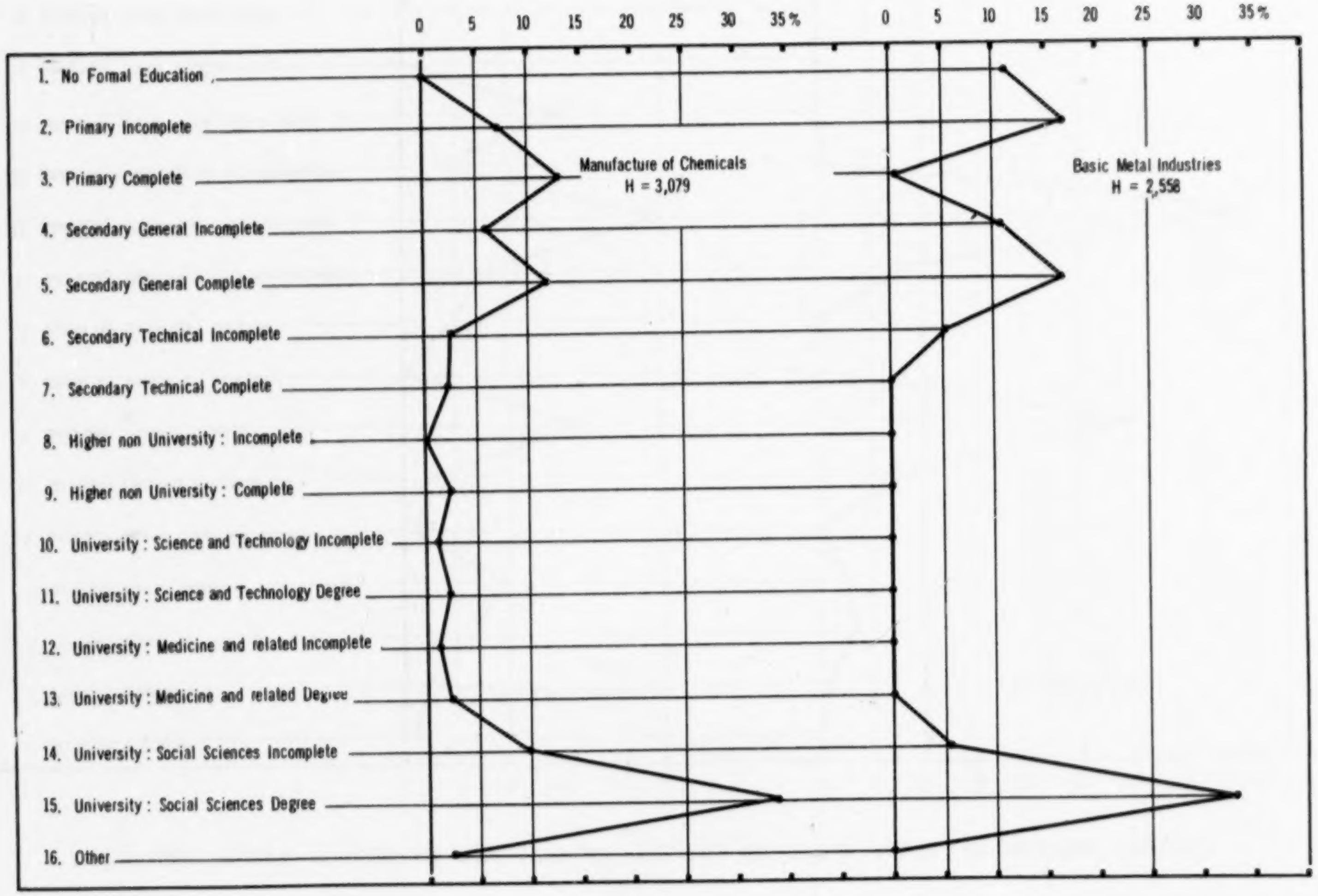
** Graphs V-1 and V-3 are almost exactly superimposable.

*** Their educational profile is characterized by significant proportions at levels 7 to 13 in the chemical industries, but not in metals: see Graph V-2.

**** The peaks corresponding to the lowest levels of education on the left of the graphs.

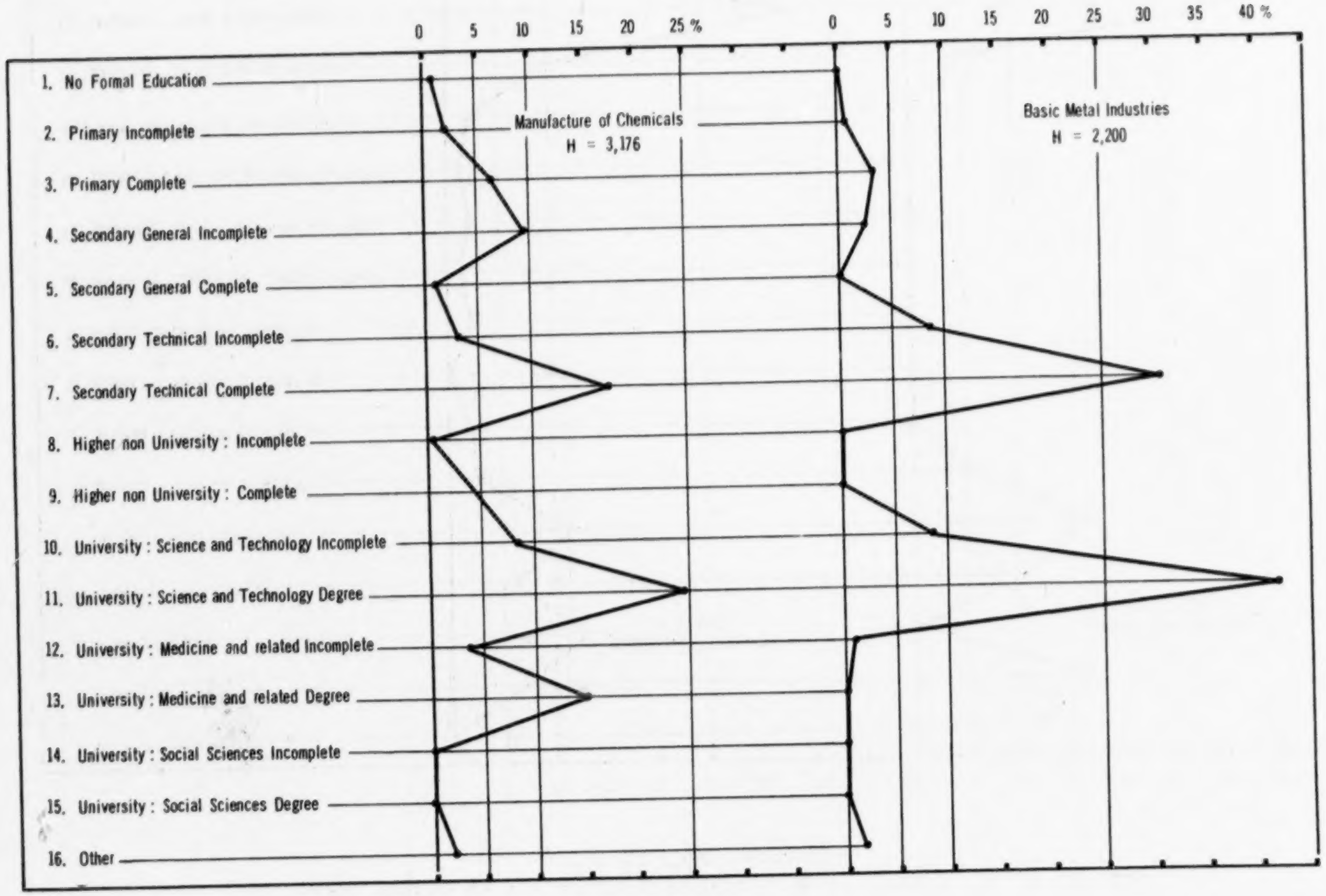
Graph V.2

EDUCATIONAL PROFILE OF NON SCEINTIFIC PERSONNEL [MAJOR GROUP 0 - (00 + 01 + 02 + 0X)]
IN TWO INDUSTRIAL BRANCHES



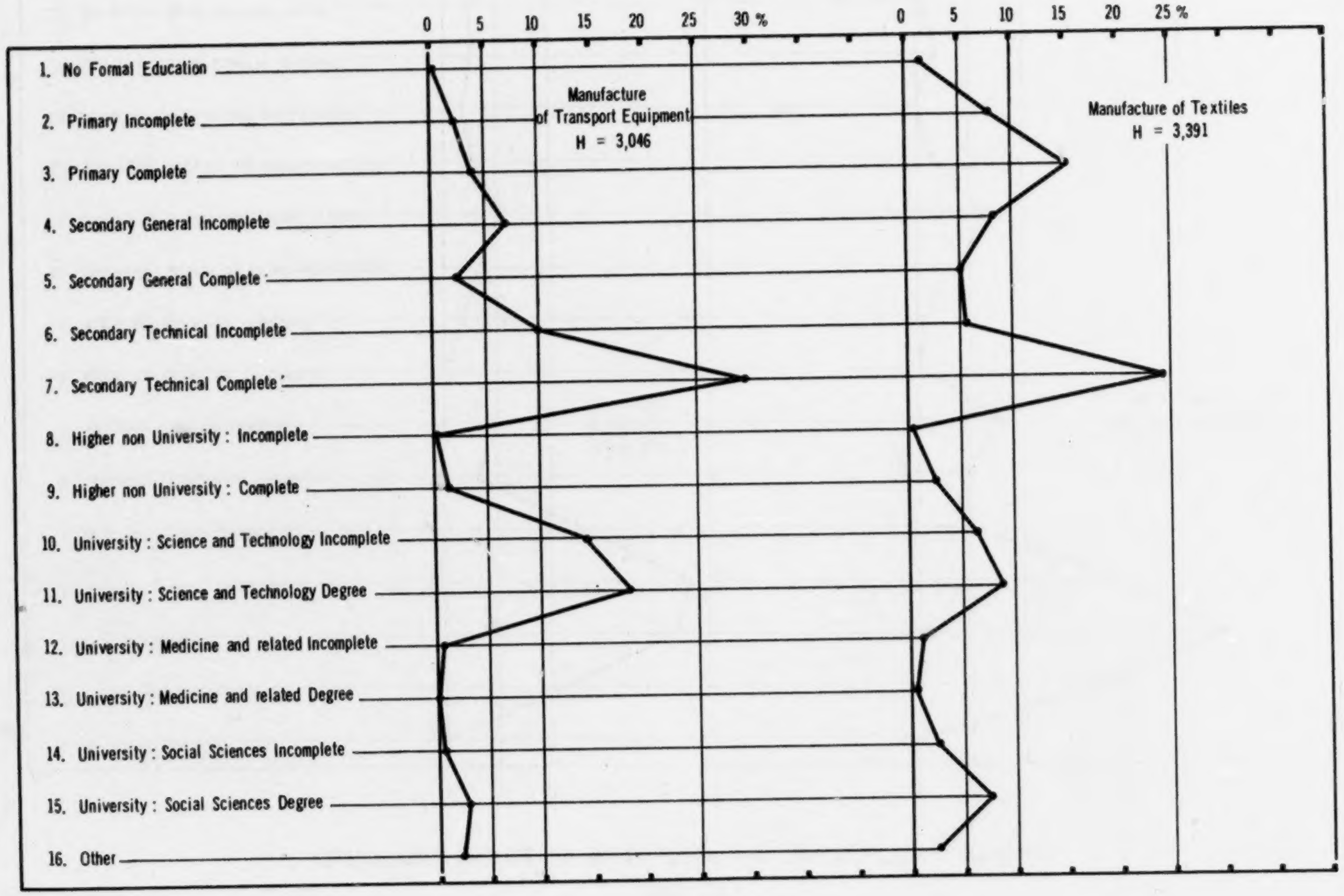
Graph V.3

EDUCATIONAL PROFILE OF SCIENTIFIC AND TECHNICAL PERSONNEL (00 + 01 + 02 + 0X) IN TWO INDUSTRIAL BRANCHES



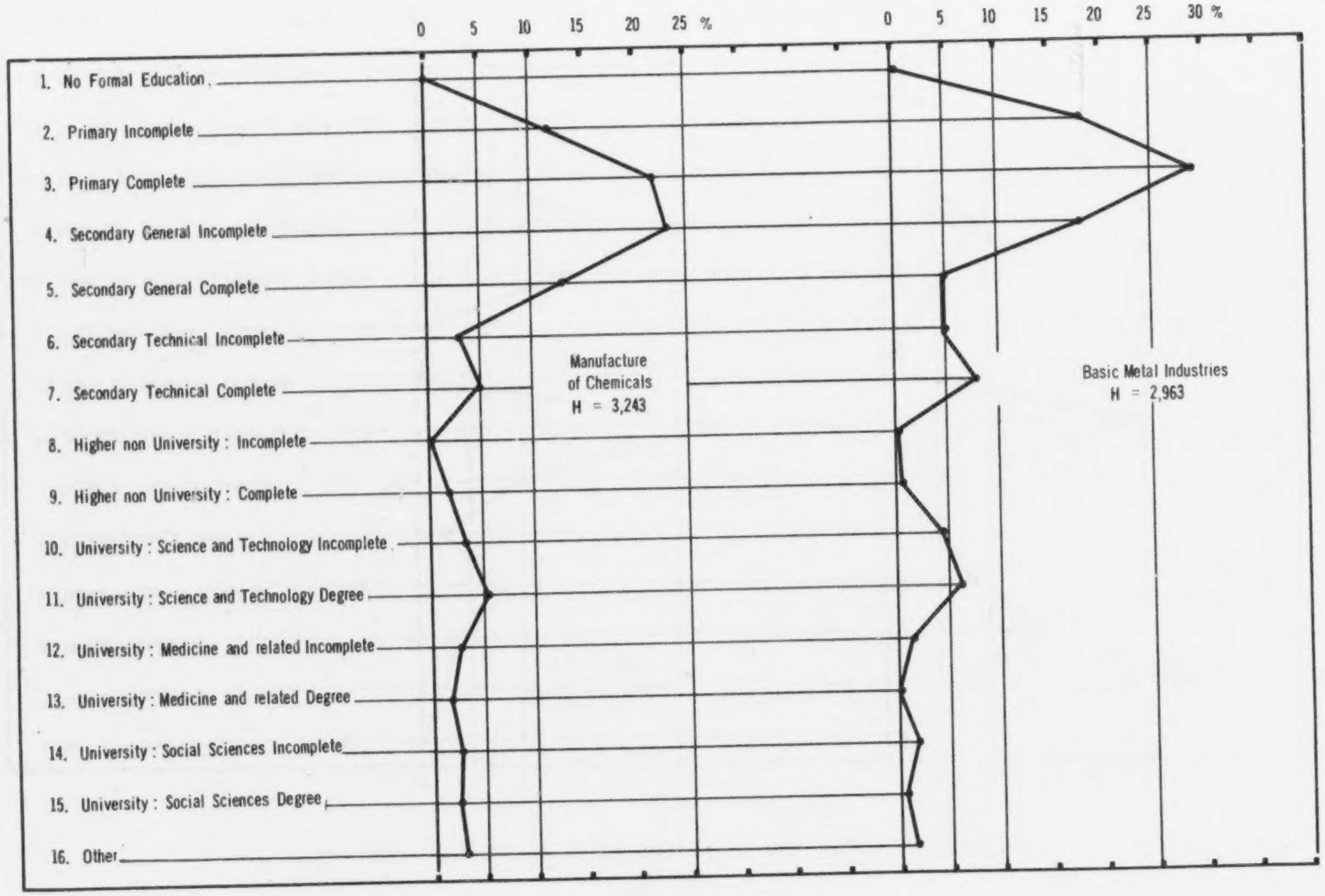
Graph V.4

EDUCATIONAL PROFILE OF MAJOR GROUP O IN TWO INDUSTRIAL BRANCHES



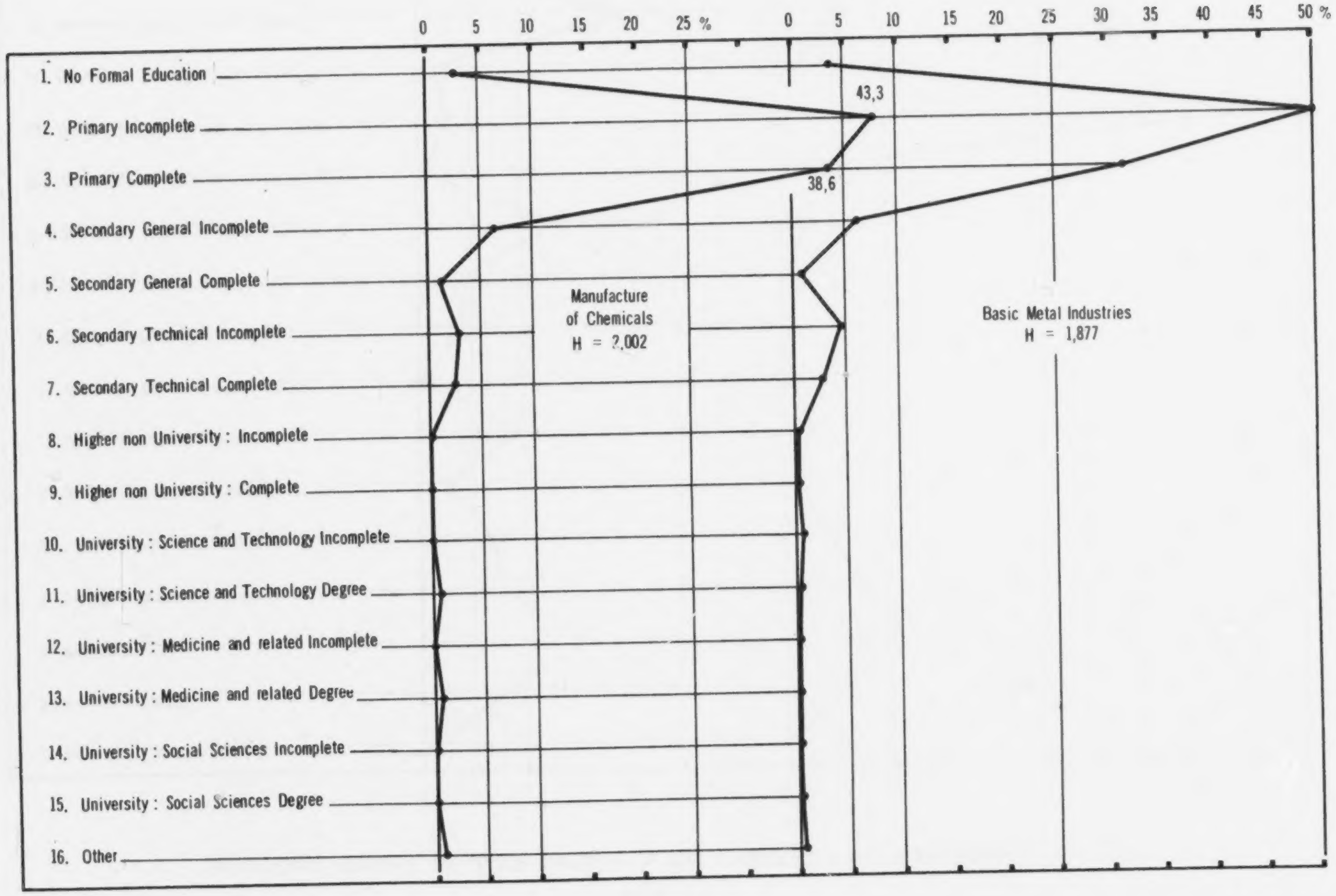
Graph V.5

EDUCATIONAL PROFILE OF MAJOR GROUP 1 IN TWO INDUSTRIAL BRANCHES



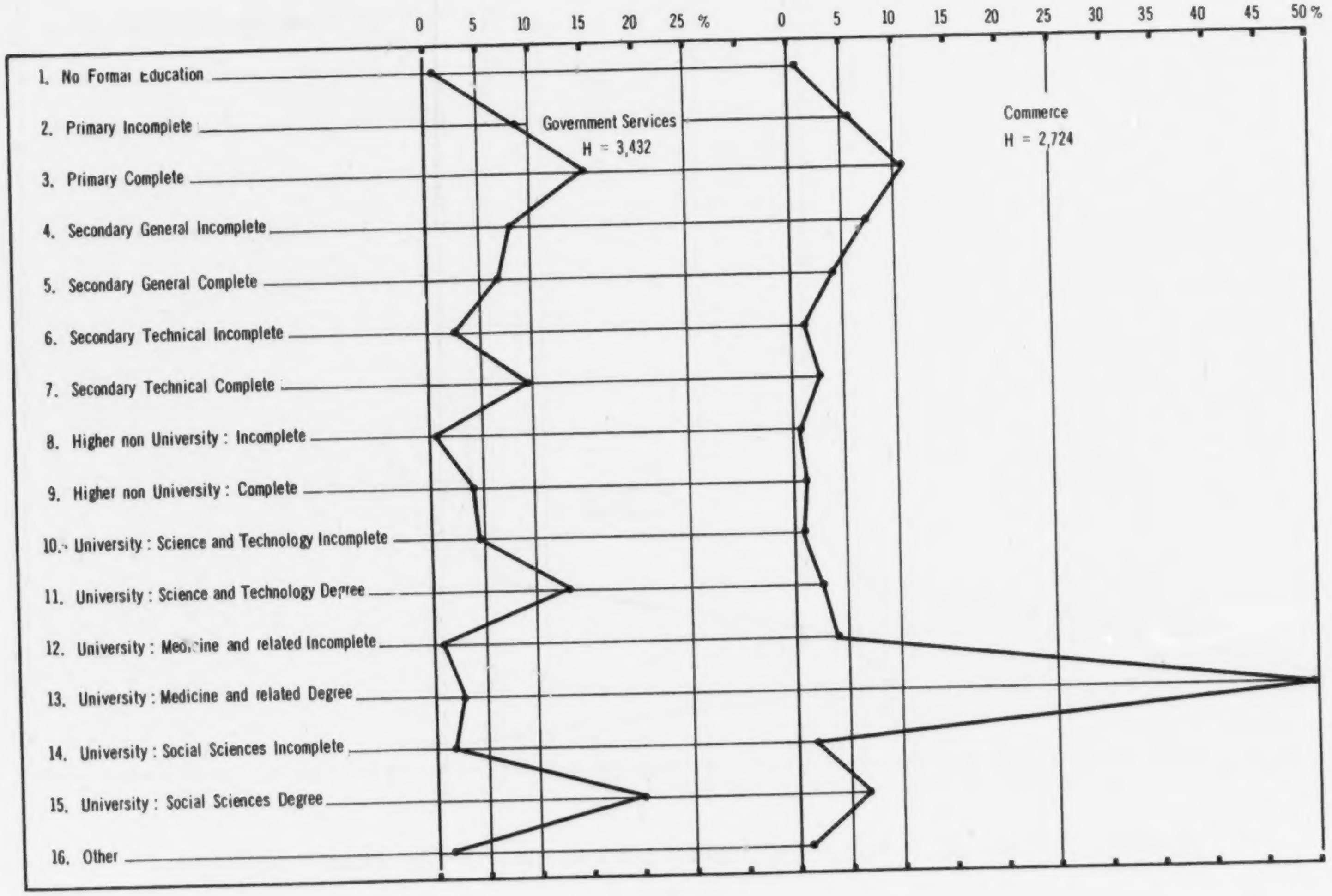
Graph V.6

EDUCATIONAL PROFILE OF THE «CRAFTSMEN AND PRODUCTION WORKERS» IN TWO INDUSTRIAL BRANCHES



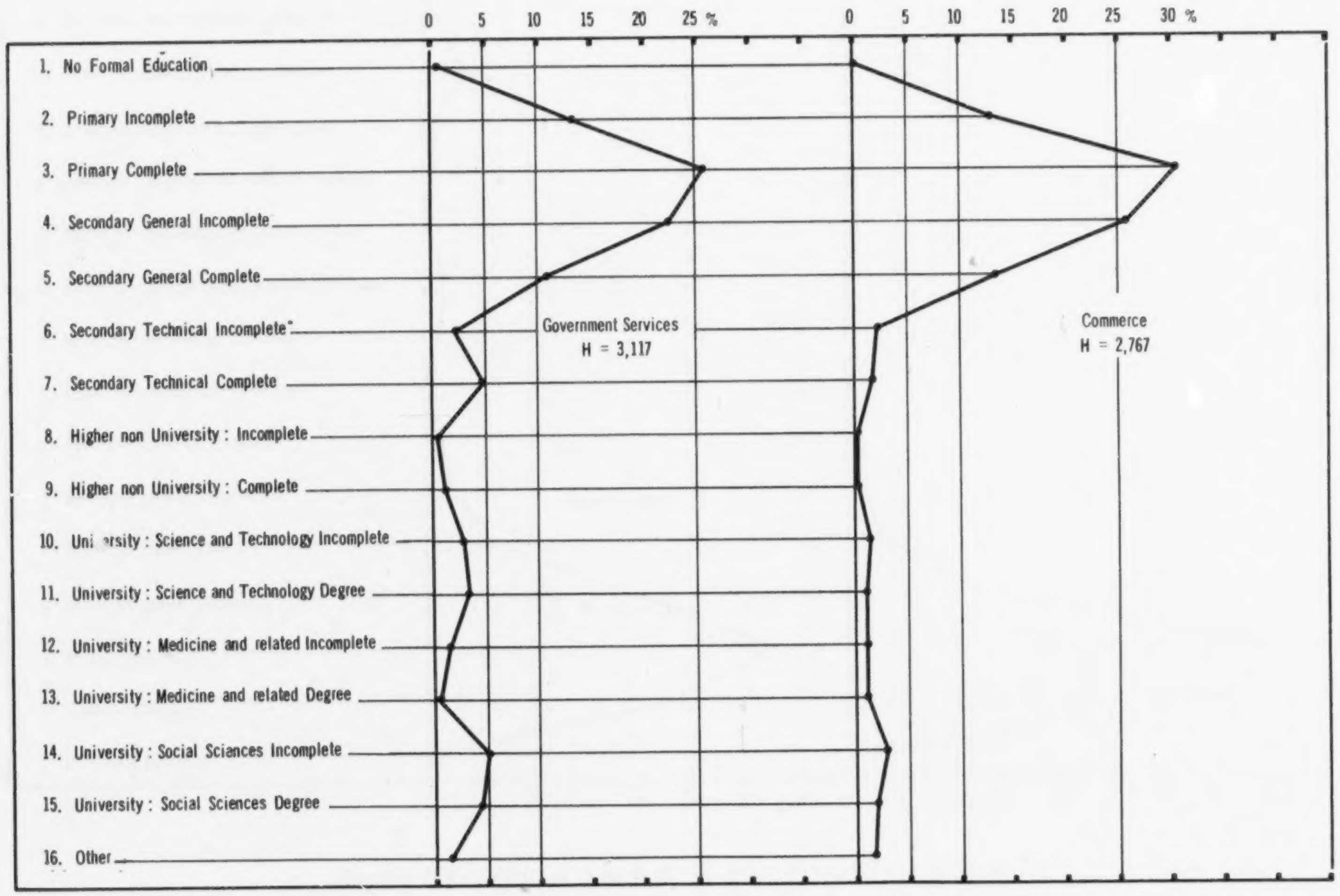
Graph V.7

EDUCATIONAL PROFILE OF MAJOR GROUP 0 IN THE «COMMERCE» AND «GOVERNMENT» SECTORS



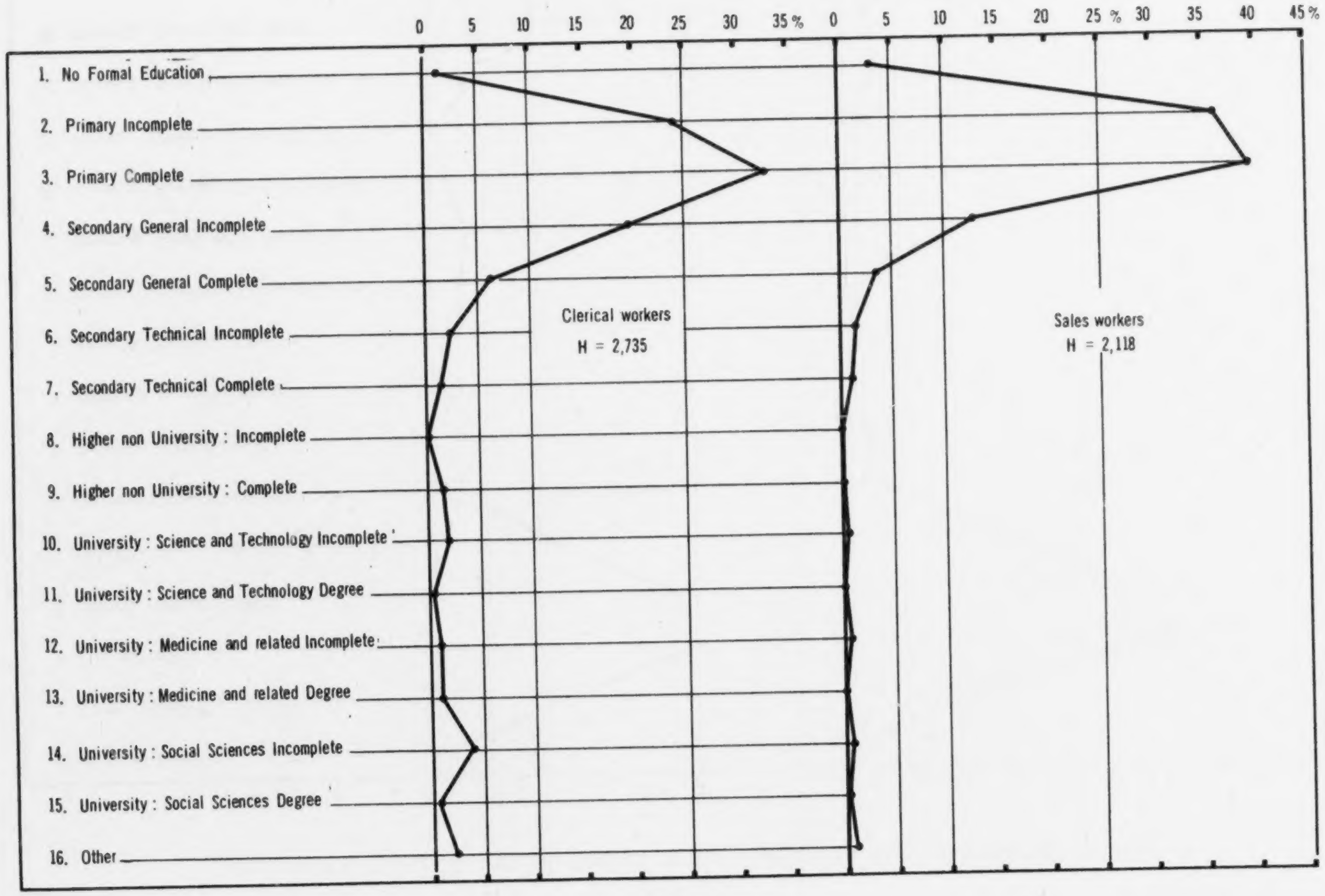
Graph V.8

EDUCATIONALE PROFILE OF MAJOR GROUP 1 IN THE «COMMERCE» AND «GOVERNMENT» SECTORS



Graph V.9

EDUCATIONAL PROFILE OF THE «SALES WORKERS» IN THE «COMMERCE» SECTOR, AND OF THE «CLERICAL WORKERS» IN THE «GOVERNMENT» SECTOR



educational profile also means an increase in the total number of years of schooling*: in Graph V-5, completed or uncompleted "general secondary" levels represent larger numbers in the chemical industries; the same applies to Graph V-6 in the case of completed primary level.

It may, therefore, be asked whether the positive productivity/entropy correlation does not merely reflect the productivity/number of years of schooling correlation, instead of a phenomenon of diversification of the educational profile as productivity rises. It can be seen that the interpretation of entropy is a tricky business, and that it is important for the calculation of this measure to be accompanied by a graphic analysis, however superficial.

Leaving productivity aside altogether, we would now propose one last example of inter-sectoral comparison of educational profiles for two selected branches of services** namely, commerce and government services. Graph V-7, comparing the profile of major group 0 in these sectors, is of particular interest: whereas in commerce, 60% of the numbers in this group are concentrated in the two levels "completed primary" (10%) and "completed university course in medicine" (50%)***, in government services, there are equivalent proportions at the following four levels: primary, technical secondary, university science graduates and university arts graduates. Here again, the respective values of the entropies reflect this state of affairs.

The educational profile of "administrators and managerial workers" for both sectors is shown in Graph V-8. The entropy is higher in government services, because appreciable proportions of the numbers in this group are beginning to emerge with high levels of education.

Lastly, Graph V-9 compares the profiles of the occupational groups which are the largest numerically speaking and are "characteristic" of the two sectors, namely, sales workers in commerce and clerical workers in government services. The phenomenon noted in the previous paragraph here operates in favour of clerical workers.

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* Because peaks would emerge at the highest levels of education in the middle of the graph.

** As we saw, the entropy/productivity correlation was valid only for certain branches of industry.

*** Representing virtually all the qualified dispensing chemists.

XXII

CONCLUSIONS

Looking back on this rapid survey of measures of association for cross-classifications, it is hard to avoid a certain scepticism in face of the sometimes contradictory results.

First, we find that the degree of disaggregation of the occupational classification may change the direction of the trend over time of the association measured by λ. *

Similarly, when the association is calculated with relative frequencies, i.e., when the influence of the occupational structure is eliminated, the trend of λ (over time or space) and of γ (over space) does not always conform to the trend observed with absolute frequencies.

Furthermore, the occupation/education association has no significant correlation with an economic indicator like labour productivity, save in respect of the sub-groups of major group 0. The influence of "professional workers", or, even more widely, "white-collar workers" on the closeness of association is confirmed by its correlation with the proportion of such workers in total employment.

More definite conclusions may perhaps be drawn from the comparisons between the educational profiles for a given occupation in different economic sectors: if the comparisons are confined to industrial sectors, high productivities generally correspond to educational profiles showing appreciable proportions of the total numbers at several very different levels of education. ** We gave examples showing that this observation might have different meanings according to the sectors considered.

To sum up, while this type of measure may sometimes be very useful as an indication of trends in highly specific contexts, it can be seen how misleading it would be to use it as a basis of argument to lay down the future orientation of educational planning. It would be more interesting to follow the path of systematic study, by countries or on an international basis, of those celebrated educational profiles, which constitute, when all is said and done, the most flexible and adaptable instrument for manpower forecasting. There is nothing to prevent their being improved by the addition of levels of informal education, the introduction of age-groups, etc.

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* Not to mention the increases in absolute value of λ whenever the classification becomes more detailed.

** We call this a tendency to equi-probability of the different levels of education in each occupational category.

Part Six

CONCLUSIONS

Before trying to draw the main conclusions from the preceding analysis, it may be useful to recall the following points, which have been the rationale underlying the presentation and content of the study:

- The available data have been used as extensively as possible; this has resulted in the testing of a great number of equations which are not all of equal value;

- The study has not limited itself to only identifying relationships useful for forecasting purposes, but also to those which could give clues as to the observed constellations of occupational and educational structures of the labour force. This approach has added to the multiplicity of equations presented;

- In general our approach to the problems to which this study has addressed itself can be labelled as impirical.

The purpose of this final Part of the study is (i) to review the main results; (ii) to deal very briefly with some of the more obvious objections and (iii) to broaden the perspective and to fit the present results in the wider frame of educational planning and policy.

Thus it is hoped to show that this study is not a blind alley, but rather a stepping stone towards more comprehensive future research.

XXIII

BASIC INTERRELATIONSHIPS REVEALED BY THE STUDY

The purpose of this chapter is not to summarize the findings yielded by the preceding analyses. This has already been done at the end of each of the Parts of this study. It would appear more fruitful to attempt to draw from the massive analysis undertaken a possible type (or possible types) of causal structures governing the relationships between the occupational and educational structures and the economic and technological indicators.

1. REVIEW OF MAIN RESULTS

The following points are summarized in diagram VI-1. They should of course be accepted with caution while keeping in mind the reservations made throughout the preceding text.

a) Very roughly the economic and technological indicators (n) account for 50% of the variance in Ljk/L: arrow 1.

b) Arrow 2 indicates that (n) accounts for 10 to 80% of the variance in the occupational percentages: Lj/L, depending on the case.

c) When Lj/L is substituted for (n) as the explanatory variable, the weight of the occupational percentage accounts for 25 to 85% of the variance in Ljk/L, depending on the case: arrow 3.

d) The influence of (n) on the educational percentages alone (Lk/L) is shown by arrow 4: from 40 to 70% of the variance.

e) Lk/L can be viewed as a function of the annual flows from the educational system into the labour market (arrow 5). Ljk/L can therefore be made to depend also on the availability of graduates: arrow 6 represents this relationship which can be considered as the model of the occupational choice of graduates discussed in Chapter XII.

f) It has become clear at this stage that Ljk/L depends simultaneously on (n) and Lk/L - arrows 1 and 6 - or on Lj/L and Lk/L: arrows 3 and 6. Moreover, one of the conclusions reached in Chapter XIII of the study was that the influence of Lk/L is largely dominant: heavy arrow 6.

g) We will point in Annex C to the significance of technical coefficients: Lj/X, Ljk/X and Lk/X. To anticipate, the coefficient Ljk/X stands in a tautological relationship to Ljk/L through

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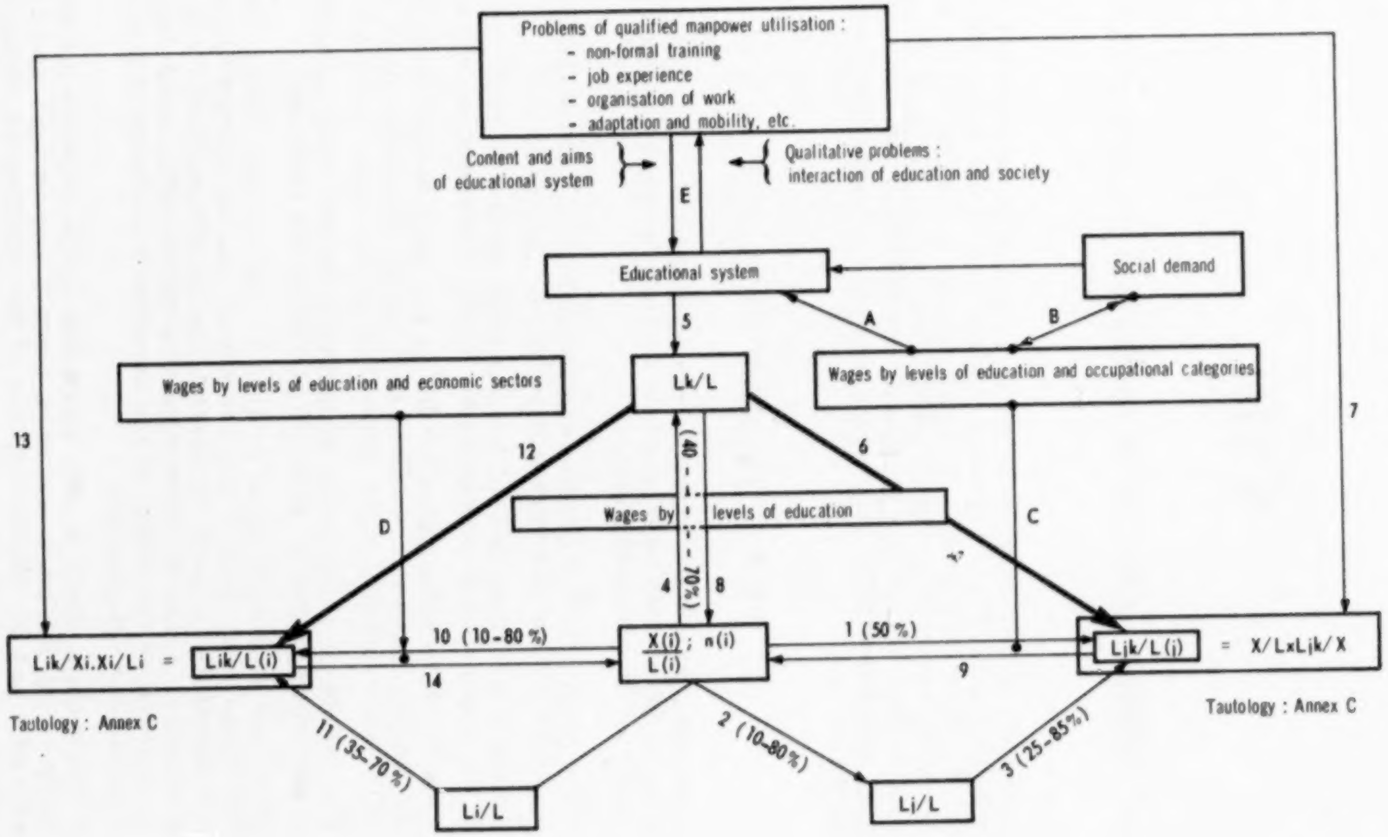
DIAGRAM VI.1


Problems of qualified manpower utilisation :
- non-formal training
- job experience
- organisation of work
- adaptation and mobility, etc.
Content and aims of educational system
Qualitative problems : interaction of education and society
E
Educational system
Social demand
A
B
5
Lk/L
Wages by levels of education and economic sectors
Wages by levels of education and occupational categories
13
12
6
7
D
C
Wages by levels of education
(40 - 70%)
4
8
10 (10-80 %)
14
1 (50 %)
9
Lik/Xi.Xi/Li = Lik/L(i)
X(i)/L(i) ; n(i)
Ljk/L(j) = X/LxLjk/X
Tautology : Annex C
Tautology : Annex C
11 (35-70 %)
2 (10-80 %)
3 (25-85 %)
Li/L
Lj/L

X/L. These coefficients may therefore be considered as residual of the equation $Ljk/L = f\ (X/L)$. To obtain further knowledge of these coefficients - a requisite for improving this basic equation - they should accordingly be made to depend on factors independent of X/L: arrow 7.

h) Finally, attempts to fit a production function in order to bring out the effect of Lk/L - and hence of Ljk/L - on levels of economic and technological development will be found in Annex D: arrows 8 and 9. The high degree of collinearity between the various Lk/L's, however, will prevent any satisfactory conclusions to be drawn from these results.

If the fairly similar results obtained in Part IV are now taken into account, the system can be generalized by introducing the economic sectors (i):

i) Thus the sectoral economic indicators (n_i), account for the widely fluctuating part of the variance in Lik/L: from 10 to 80%, depending on the sector and level of education (arrow 10).

j) When the sectoral structure of employment (Li/L) is substituted for (n_i), it accounts for 35 to 70% of the variance in Lik/L: arrow 11.

k) Lik/L moreover depends on the stock of graduates available in the labour force, arrow 12 represents the model for sectoral choice of graduates, as discussed in Part IV.

l) It will then be clear that Lik/L simultaneously depends on Lk/L and n_i - arrows 12 and 10 - or Lk/L and Li/L: arrows 12 and 11. The dominant effect of Lk/L is indicated by the heavy arrow 12.

m) The sectoral educational coefficients may be regarded as residual values of the equation $Lik/Li = f\ (Xi/Li)$ for the same reasons indicated for the total economy: see Annex C. To obtain further knowledge of these coefficients - a requisite for improving the basic equation - they should accordingly be made to depend on factors independent of Xi/Li, a complementary analysis which here has only been suggested: arrow 13.

n) Finally, the fitting of a production function in order to bring out the effects of Lik/L on levels of development will be found in Annex D: arrow 14. Here again, however, the collinearity problem looms large.

Owing to their general character, some of the foregoing findings need to be further developed, and if used may give rise to certain ambiguities which need to be made explicit.

2. ADDITIONAL OBSERVATIONS CONCERNING THE NATURE OF THE FINDINGS

i) The problem of suboptimality

The type of international cross-section approach used throughout the study can and is frequently criticized because it uses observed values which are not necessarily optimal values. Such criticism applies of course with equal force to comparative analysis at the establishment level, to time-series analysis - in short to any kind of analysis which accepts the observed past and present situation as a datum for future action.

a) Although the regression lines as estimated in the previous Parts of this study could indeed frequently be labelled "averages of imbalance", they are still preferable to an isolated imbalance whose direction and magnitude are unknown;

b) Secondly, and once again, we have never advocated any mechanical application of the regression equations. However, the regression lines should be considered as indispensable reference values, from which an optimum value could be approached by means of "individual" analysis at the national level. As an illustration of this point, it will be clear that in regard to Japan, a permanent extreme case in all scatter diagrams, the results of any regression equation based upon international observations can but be one among other determining factors. This example moreover points to the importance of analysing on a case study basis those countries that are situated in extreme positions with respect to the regression line. This has not been possible in the framework of the present study.

ii) The identification problem

This problem has already been referred to in Part I. In Parts III and IV attempts have been made to assess the respective effects on the educational profiles of the "push" factors originating from the expansion of the educational system, and of the "pull" factors as reflected by economic needs for qualified personnel.

The general conclusion which could be drawn from an equation like $Ljk/Lj = f(Lk/L, Lj/L)$ was that in the vast majority of cases the influence of the available supply (the "push" factors) strongly prevailed. This should not come as a surprise when it is remembered that no country has ever seriously subordinated the growth of its educational system to strictly economic needs. Possible exceptions are the very few socialist countries among our observations.

It would be absurd to maintain that the equation $Ljk/Lj = f(Lk/L, Lj/L)$ resolves the identification problem by equating the "supply" to Lk/L and the "demand" to Lj/L. It is but the most complete statistical expression of the occupation/education matrices. It is mainly effective in showing that the educational profile of occupational categories is a function both of the economic indicators and of the educational stock embodied in the labour force. This means in practice that manpower forecasts by levels of education should always be accompanied by forecasts of the educational system's supply of graduates.

iii) Complementarity versus substitution

It will be recalled that another question mentioned in Part I was that of complementarity versus substitution. This problem is obviously related to that of supply effects mentioned in the previous paragraph. The analyses carried out in this study - both with regard to occupational

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and educational percentages and with occupational and educational coefficients - strongly suggest that possibilities of partial substitution between different types of labour exist at given levels of economic and technological development. As has already been indicated several times in the course of the analysis, other reasons besides substitution possibilities may exist to explain our findings, but the least one can say is that they cast serious doubts on the complementarity hypothesis usually adopted in manpower forecasts. This is consistent with our conclusions of the previous paragraph.

XXIV

THE STUDY IN PERSPECTIVE

This publication arrives at a moment when the approach towards manpower and educational planning is going through a reappraisal. The emphasis is shifting away from the mere and rather naive quantification of "targets" (so many engineers, etc., required, so many secondary school-leavers going to apply for entry into the University) towards a more sophisticated investigation into the interrelationships between the educational process and the economic and social process. There is also a definite trend towards a closer integration of educational planning into the decision-making structure and process. These two points will be dealt with briefly in this final chapter which will thus also serve to examine the relevance of the preceding study to this more realistic approach. However, before widening the debate in this way to include the entire field of educational planning and policy problems, a few words will first be said about certain aspects of the narrower area of the economics of education, insufficiently dealt with during the preceding analysis.

1. EDUCATION, MANPOWER AND THE LABOUR MARKET

Certain problem areas have hardly been touched upon in the course of this study. One of them relates to the actual functioning of the labour market and the incentives - both monetary and non-monetary - that prevail. One of the more important factors in this respect - namely wages - has been conspicuous by its absence throughout the analysis. A very brief account will, therefore, be given of how wages and salaries are usually dealt with in the economics of education, and of how they might be introduced in the present analysis. This problem cannot be dealt with in isolation from the educational "push" factors which, as was noted, have a considerable impact on the educational profiles of occupational categories and on the qualification structure of the labour force in general: arrows 5, 6 and 12 depicted in diagram VI-1.

We will start by reviewing briefly how up to now the salary structure has been taken into consideration in the field of the economics of education before making one or two suggestions as to complementary ways of doing so.

a) The most systematic way of dealing with the salary structure has been called the rate-of-return approach which consists of an application of cost benefit analysis to investments in education (both on the private as well as on the social level). It is not necessary to describe this method; it will suffice to refer to the supporters of this approach*, who incidentally are the first to point out its limitations. **

In our diagram VI-1, arrow A symbolizes the direct impact which the salary levels by qualification can exert on the development of the educational system through cost-benefit analysis. We shall not here take up the now classical objections to this approach, such as the difficulty of assigning the exact share of additional earnings due to differences in educational achievement *alone*; the distortions that may exist in the functioning of the labour market which may compel the adoption of shadow prices, which however, is not an easy task, etc.

b) The above method constitutes an *ex post* check on the efficiency of investment embodied in educational facilities and may, therefore, provide a signal for the desired direction of change in the educational system. On the other hand the existing wage and salary structure may affect development of the educational system *ex ante* through its influence on the so-called *social demand* for education: arrow B. Social demand for education depends on several factors whose respective weights are difficult to assess because they all largely interact, such as the various family characteristics (father's occupation, parental education, size of family, etc.); innate ability and also, of course, the number of places available at the different levels and branches of education. *** There can be no doubt that the monetary and non-monetary incentives prevailing - and anticipated - in the labour market play a role in shaping and directing the social demand for education. Private rate-of-return calculations can give us a clue in how far the social demand is being influenced by monetary incentives, but by those alone. Quite clearly, therefore, manpower forecasts have to be accompanied not only by social demand forecasts, as mentioned already above, and taking account of the factors just mentioned, but also by a careful analysis of the incentives at work in the labour market.

c) Coming back to the problem of the salary structure, one way of introducing this explicitly into an analysis as the one undertaken in the present study might be as follows:

Let: Wk be the index of the average salary level for persons in educational category k (average salary level of total labour force = 100);

Wik be the analogous index at the economic sector level;

Wjk be the analogous index for persons in occupational category j with education k.

It would then be interesting to examine whether systematic changes can be observed in the value of those indices when countries at equivalent levels of development show considerable differences in the sizes of their occupational and educational categories.

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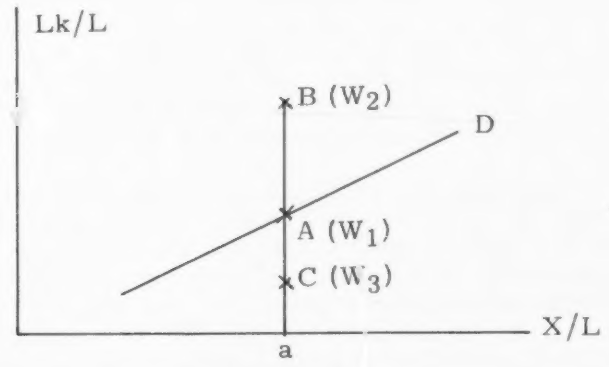
* The standard work on the subject is G. S. Becker's *Human Capital. A theoretical and empirical analysis*, with special reference to Education, Princeton University Press, 1964.

** See Mark Blaug, "The Rate of Return on Investment in Education in Great Britain", *The Manchester School of Economic and Social Studies*, September 1965.

*** For a general discussion of this question, see C. Arnold Anderson, "Sociological factors in the Demand for Education" in *Social Objectives in Educational Planning*, OECD, Paris, 1967. For an illustration on the national level, see the *Robbins Report on Higher Education*, Appendix One, Part II: "Factors influencing entry into higher education". See further various background papers prepared for the OECD's Conference on Policies for Educational Growth (June, 1970).



For example, if D is the regression line giving the best fit between X/L and Lk/L, and W_1 is the salary index for Lk in Country A with productivity level a, then it would be of interest to see whether for countries B and C with the same productivity level $W_2 < W_1$ and $W_3 > W_1$.

Here again, D does not necessarily constitute an optimum situation but may nevertheless be taken as one of the criteria to determine the shadow prices to rectify the salary structure in view of rate-of-return analysis.

The above type of analysis would enable us to obtain a precious insight into the impact on relative salary differentials of what we have called the educational supply effect. A knowledge of this impact is necessary if rate-of-return analysis is ever to become a serious forecasting instrument.

2. INTERRELATIONSHIPS BETWEEN THE EDUCATIONAL PROCESS AND THE ECONOMIC-SOCIAL PROCESS

We will now widen the perspective even more and try to look at this study from the point of view of educational planning and policy. The earlier, rather sterile, debate about "approaches" to educational planning is characterized in a passage of the Robbins Report on Higher Education:

> " In principle, the problem of estimating the number of places required can be approached in two ways: by considering what supply of different kinds of highly educated persons will be required to meet the needs of the nation, or by considering what the demand for places in higher education is likely to be. We have decided that the second approach presents the sounder basis for estimates.

We have found the first approach impracticable. For, while it is possible, for a number of professions and over a short term, to calculate with a fair degree of precision what the national needs for recruits will be, we have found no reliable basis for reckoning the totality of such needs over a long term. (.......) Here we would only emphasize that, although we have not made national needs the main basis of our estimates, this must not suggest that we have any doubt of the value to the country of a greatly increased stock of highly educated people and of the absolute necessity of a great increase in the present provision of places in higher education if this country is to hold its own in the modern world."*

This perfect example of mutual exclusive approaches (in this case between the so-called social demand and the manpower needs) is now making place for a more integrated, subtle and probably more realistic approach, concentrating on the interrelation between supply of graduates, occupational choice, salary structures, etc., as was already suggested in section 1 above. In the past the impression has sometimes been given of an uni-directional sequence of events between social demand, manpower needs and earnings. Clearly, the direction is not unilateral, but there is a mixture of autonomous development on the one hand and continuous feedback of each of these variables on each other on the other hand. One of the more interesting aspects of the preceding study is to have pointed to some of these features and to have demonstrated their existence. What have been called in this Report the educational push factors reflect an autonomous development of the education system (autonomous relative to the economic and technological process, not relative to sociological and psychological factors, see below). These educational push factors may result in changes in the occupational choice of school-leavers and graduates and thus on the educational profile of occupations and sectors. This phenomenon was illustrated in Chapters XII and XVI of this Volume.

It is the above mechanism coupled with the very important educational expansion of the last 15 years - which is bound to continue in the future - which has led certain people to talk about the spectre of over-supply of qualified personnel. The usual caveat in this kind of reasoning is that it is based on the present occupation - education relationships, whereas - as has been shown in this Report and as can be observed in those countries which have time-series available - these relationships vary not only according to the level of economic-technological development, but particularly to the level of educational development.

The above considerations do not necessarily mean that, whatever the development of the educational system as compared with the occupational shifts that take place through the economic and technological development, no problems are likely to emerge and that no active interventions will be necessary. One of these problems may very well be the important individual frustrations caused by changes in the occupational "choice" of graduates which may also have an impact on the personal income distribution of groups with different levels of schooling. Such a development may stimulate in turn the discussion about diversification and restructuring of tertiary education.

At the very least, therefore, and as was already implicit in the discussion presented in section 1 of this chapter, the implications of a given educational policy on the occupational choice and on relative earnings should be analysed. This would still imply doing many things one has been doing during the 1960's - such as forecasting "social demand", occupational structures, and even the personal income structure- but without the rigidities inherent in the one-way analysis. However, the kind of planning framework one should really be moving towards would bring explicitly into the picture the three following sets of variables:

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* Robbins Report, op. cit., p. 48.

i) characteristics of the population before entering the education system, such as social and regional origin, I.Q., education of the father and mother, etc.;

ii) school and teacher variables, and

iii) what happens to the individuals once they leave the educational system: occupational choice, occupational mobility, earnings, etc. Such an approach would, therefore, be concerned with the dynamic interrelationships between "ability, opportunity and career". A certain number of major studies have appeared during the last few years, which highlight a series of issues with respect to how people learn, how their learning is translated into productive activity, how ability and home environment interact with schooling in the formation of competencies and how far schooling contributes to earning power as compared to other relevant factors. *

During the past period of educational growth a number of studies have been carried out concerning the various aspects of the educational system in the economic and social context: cost-benefit or rate-of-return studies; educational participation analysed by social groups; studies of the occupation-education relationships as presented, for example, in this study, school characteristics - achievement studies of the type mentioned above; studies of levels of expenditure and sources of finance, etc. It is time to try to put these pieces into some sort of order so as to establish what it is one knows and does not know about the relationship of educational processes to the level and distribution of income, and to other social and economic features of a country. Are there not, for example, some necessary relationships between the rates of return findings, the distribution of income and the shifts in the educational distribution of the population and the labour force ?

The above appears to be the wider framework of analysis of which the various bits and pieces done so far - including the present study - is only a part. It is this wider framework one should be moving to in the future. Such a more comprehensive approach would also be much more relevant to the decision-makers.

3. EDUCATIONAL PLANNING AND DECISION-MAKING

One of the more striking facts of the past decade has been the virtual absence of the decision-maker from the "educational planning" process. This has resulted in a rather "passive" attitude of those responsible for educational planning. The educational planning documents that have

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* Such an approach is under study in the Centre for Educational Research and Innovation of the OECD.

appeared in the 1960's have mainly concentrated on extrapolating easily quantifiable variables supposed to reflect the external pressure on the educational system, supplemented at best by a more or less rudimentary analysis of the educational system itself. The dynamic interrelationships between the various forces at work - in the sense outlined in the first two sections of this chapter - have hardly ever been examined with any degree of detail and/or sophistication.

This has led to a paradoxical situation: on the one hand we have seen a proliferation of long-term educational forecasts concentrating on very few global and quantitative factors, such as total enrolments, number of graduates and school-leavers, total educational expenditure, etc. Demographic forecasts and, sometimes, a manpower forecast constitute the guideposts with respect to the economy and the society in general. On the basis of such forecasts, decisions are sometimes taken as to the number of places to be provided in the education system, as well as concerning teachers and other resource input implications. On the other hand, and at the same time, more qualitative changes are being introduced, such as the trend towards comprehensive education in many countries, curriculum reforms, technological changes in the narrow sense of making education more capital intensive, etc. These changes are introduced to meet a variety of objectives, which are sometimes not even made explicit. It is not always easy to find out how far the actions undertaken are consistent with the objectives and among each other, what their major future implications are likely to be both in and outside the education sector, and what the role of the above-mentioned quantitative forecasts has been, if any, in shaping these decisions. They, moreover, have rarely attached to them even a minimum of consequential analysis to assess their major future implications. Instead of one world in which planning is a rationalization technique for decision-making, we have been faced with two worlds, one busying itself with planning approaches, the other with taking decisions.

What have these general considerations to do with the substance of the preceding study ? The answer to this question is twofold. In the first place forecasting only the occupational and educational structure of the labour force is of no policy relevance unless one has decided to gear the educational system mainly to the economic requirements. If this is not the case, the question becomes: where do we want to go with our educational system and if we decide to go in a certain direction what are the implications both for the education system and for the society and the individuals that compose it ? This throws the main responsibility into the lap of the educational decision-maker and the educational planning activity should go beyond the quantification of objectives and consist of exploring the consequences of alternative educational policies on at least the range of variables outlined in section 2 above. The present study has shown the important independent effect education expansion patterns have on the occupational choice of graduates. In this sense it has clear relevance to the problem discussed in this final chapter. In this sense also it may have made a modest contribution to letting educational planning come of age.

Part Seven

COMMENTS ON THE OECD STUDY

A first draft of the preceding study was discussed by a group of critical friends. Four of them were kind enough to write up their impressions. This seventh and last part of the present volume contains their contributions. The papers are, of course, published under the responsibility of the respective authors. The secretariat takes this occasion to thank them for their constructive criticisms. Attention is drawn to the fact that all references in the following papers refer to the first draft of the OECD Study (ref. no. DAS/EID/69.16).

1

EDUCATION AND MANPOWER PLANNING REVISITED

by

Mary Jean BOWMAN

Over the past decade there has been a proliferation of endeavours to relate education, productive skills, and economic development, along with schemes to plan human-resource formation in line with economic development goals. Though it is generally agreed that economic growth is a basic societal goal in the realization of which education plays a part, there is less agreement on what kinds and levels of education contribute, and in what ways, or under what circumstances, to growth. Again, few would challenge the belief that government must be involved significantly in education, or that educational policies should be worked out "planfully". The near-universal agreement breaks down, however, when we come to particulars such as who or what agencies should plan this or that aspect of education, to what purposes, on behalf of whom, and in what ways. There are complex relationships among education, productive skills and economic development, and many thorny philosophical issues surround education; in addition there is diversity among those who work in this area with respect to backgrounds in economic training and bureaucratic experience. It is, then, hardly surprising that dialogue, where it has occurred at all, has been characterized by large elements of "non-communication". OECD has been one of the participants in this "non-communication", but it has also, and increasingly, acted to enhance effective interchange of views.

It is against this background that I have interpreted the invitation to write a dual commentary on (i) the foregoing study of "Occupational and Educational Structures of the Labour Force and Levels of Economic Development" (hereafter referred to as the Report), and (ii) to range more widely over the history of the economics of education with special reference to its implications for human-resource-development planning. In order to maximize communication, I decided to merge my commentary on the Report into the broader analysis as far as possible.* This can be fruitful because of several characteristics of the Report:

a) The Report is concerned not with refinements of techniques but rather with basic factor input and output relationships in association with levels of economic attainment, seen especially in their implications for educational planning and for manpower-development strategies. So are these comments. Refined assessments of particular techniques or computational models claim attention only if they clarify a fundamental point about economic analysis or the logic of planning.

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* Comments on details were provided informally; they are not repeated here except as they are illustrative of a point of more general interest.

b) The Report provides an orderly and unbiased empirical cross-country analysis of relationships that have been widely discussed and debated and are highly relevant to educational and manpower planning.

c) The Report nevertheless retains features of the initial "manpower-requirements" orientation that marked OECD activities. That point of departure is evidenced in the questions asked (and in some of those omitted), in the way the statistical analysis has been set up, in what the authors find "puzzling" (or, for that matter, what they find non-surprising), in what they take note of as "hopeful" or "unfortunate", and even in the ways in which they express themselves. Read from a different perspective, the Report thus illustrates differences in ways of thinking and exemplifies some associated problems of communication.

d) The authors have sought genuinely to relate their work, in some degree at least, to those who have other starting points or other orientations. Their efforts in this direction, though limited, provide a useful entry to discussions of important problems, modes of analysis, and kinds of potential manpower strategies that have commonly been ignored (or distorted) by more conventional manpower planners.

The most important matters that the Report does not touch upon, lacking in much of the work done by economists with other approaches as well, concern the dynamics of economic development: the distinctively dynamic contributions of education to development; the extent and implications of continuous skill obsolescence; and the entire logic of decision-making under uncertainty (whether societal or individual). Although these matters are pertinent on all topics - the last of them lying at the very centre of planning processes - with minor exceptions I shall defer comment on dynamic processes and uncertainty to the last section of this essay, for the moment stressing only that projection of a rising demand for skilled manpower (for example) is not in itself analysis of the dynamics of development.

1. PERCEPTIONS OF ALTERNATIVES AND ELASTICITIES OF SUBSTITUTION

The Elementary Logic of Planning

If there is no room for choice, there is no room for planning; planning is the deliberative choice among alternative actions. To the economist who has made neo-classical economics and decision theory his starting point, finding his intellectual home more readily among the human-investment theorists than among the manpower-requirements projectors, decision-making is not only the heart of planning; it is the heart of economics as a behavioural science as well. "Planning" is something that is going on continuously, at all levels in a society, whenever men deliberate concerning the future effects of taking one line of action rather than another.* To such an economist - and this is where

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* See the discussions of the nature of planning in C. Arnold Anderson and Mary Jean Bowman (1964) and Y. Dror (1963).

I must count myself - it is extremely difficult to understand how anyone can think about planning without explicit recognition of the notion of "opportunity cost". All costs of an action are, in their very nature, the value (monetary or non-monetary) of the most desireable alternative that is given up or "foregone" in opting for the alternative chosen.* Nevertheless, it was only a few years ago that a battle raged over the idea of considering foregone earnings of pupils as a cost of schooling; even today the economics of this matter has eluded the notice of a fair proportion of presumptive "experts" in cost analysis, and opposition has not entirely disappeared. Given that the logic of the opportunity-cost concept in planning seems as self-evident to some of us, and indeed so important and unassailable, what can explain persistence of this argument and/or neglect of opportunity-cost logic. Sheer ignorance aside, in my judgment it is attributable to one or both of the following :

a) semantic confusion concerning the nature of the "cost" concept and its uses, and

b) differences in perceptions concerning the nature of empirical alternatives open to the central planner and associated differences in pragmatic judgments concerning the feasibility of valid opportunity-cost estimation.

This is not the place to elaborate on (a) beyond reiterating that inherently the cost concept, which refers to what is given up or foregone, is inappropriate to the measurement of what people produce; aggregation to estimate national income at factor prices is an imputed "value" accounting, not a "cost" accounting.**

Differences of type (b) are another matter, however, and they are highly relevant to ways in which men approach planning. Those who start from the assumption that there is little room for substitution among productive factors (at any given level of technology) are prone to dispense with pricing altogether***, and thereby with estimates both of benefits and of opportunity costs. Instead they turn to "quantitative planning" with emphasis on technical feasibility and consistency: is it physically possible to carry out a particular "plan" or will physical constraints block its realization? Even when they start by asking whether elasticities are in fact as low as had been supposed, they tend to pose questions in quantitative terms, without making use of wage data or market analysis. This mode of thinking is exemplified in the Report. By contrast, those who start from decision-theory economics are much more inclined to incorporate market adjustments and pricing in their analysis of manpower utilization, as well as in the "explanation" of investments in human beings and the determination of supplies of skills. Furthermore, they proceed in this manner even when exploring or working with situations characterized by very low elasticities of substitution.

* For analysis of this concept and its interpretation in the context of public decision-making see Bowman (1966).

** This argument is presented in Part II of Bowman (1966). See also the comments and rejoinder at the end of the symposium (pp. 689-708).

*** Note, however, that these same people usually make use of monetary measures of national income. Such measures can have meaning only to the extent that the valuations of their components (from which they are constructed) have some degree of legitimacy. Furthermore, monetary national income estimates entail aggregations that treat marginal valuations as if they were identical with mean values, and they count the rich man's dollar as "worth" the same as the poor man's dollar; these implicit assumptions go much further than anything required in the use of pricing for empirical analysis of resource allocation and factor substitution.

Fixed Coefficients and the Scope of Choice

The retreat from fixed-coefficient assumptions and notions of "fit" that has appeared in recent empirical work in OECD* (and in other sources as well) should mark the end of the polarized "battle of the approaches" on that issue. But even with some empirical "rapprochement", where men start from and the models and assumptions they use as first approximations will continue to make a very substantial difference. Moreover, while associations between methodological starting points and political presuppositions are not inevitable, neither are they altogether accidental. To think systematically about the basic aspects of recent efforts to plan human-resource development, or at least to approach this problem "planfully", it is necessary to see the models and the arguments in a context that recognizes distinctive modes of thought. A simplified delineation of such patterns is laid out in tabular form below. I make no apologies for returning to a broad dichotomization; that dichotomy is unquestionably very real, even though there are also convergent elements and cross-overs by a few individuals who have worked from more than one orientation and frame of reference.

The first two rows specify types of analytical models and relationships of those models to planning. Looking behind the more sophisticated modern techniques (and associated precision in specification of models such as those to which row (1) refers), we see the double heritage in economics, going back as far as the mercantilists on the one hand, Adam Smith (and Condorcet) on the other. Equally clear, in the less remote background, are associations between types of models and their elaboration predominantly in the interests of national-income accounting and centralized planning on the one hand, behavioural study of market systems on the other. It is no accident that the fixed-coefficient models and "quantitative planning" have appealed to central planners; they are the most convenient simplification for this purpose. Oscar Lange's *Economic Theory of Socialism*** was a beautiful abstraction, and totally consistent with the inherent abstract logic of benefit/cost analysis; but political considerations aside it was quite impracticable of application to detailed central planning by men with something less than omniscience. The logic of benefit/cost analysis is matched by its pragmatic usefulness, however, when central planners are more modest in the scope and detail of their plans, and content in greater degree to let the market system take on a share of the task. This presumes that individuals exercise some degree of rational judgment in their choices, and plans modify those choices primarily by altering the decision parameters for individuals and institutions - as in subsidies of varying amounts to one or another kind and level of education.

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*A systematic evaluation of arguments and evidence concerning degrees of association between skill mix and levels of economic development, and between education and jobs, was presented in my paper for the Lake Mohonk Conference, at which social scientists from various backgrounds were brought together by the International Association for the Evaluation of Educational Achievement (in May 1967). I shall not repeat that analysis here. See Bowman (1967).

**Lange (1938). This model was an attempt to provide simultaneously for equality in the distribution of incomes (or distribution of incomes according to "need") and freedom in the expression of individual preferences - all through a beneficent system of social accounting and central control of productive resources. The subsequent shift in Lange's position is of course well known.

I chose, in laying out the tabular summary, to stress as prime distinguishing characteristics the fixed-coefficient versus the more free-floating, neo-classical assumptions about underlying economic structures for two reasons; first, the distinction between assumptions with respect to substitution elasticities is in itself philosophically neutral, and investigation of the empirical evidence on this matter is a principal reason for the Report. Second, and equally important, if technical constraints were in fact very rigid, direct market pricing (and costing) would be of very little use in specifying critical parameters for public policy or central planning decisions; this is the case that has been argued for "quantitative planning" (and also, in part, for the aggregative derivation of shadow prices through dynamic linear programming or related techniques). No one has ever supposed, however, that all production coefficients were so fixed as to preclude alternatives among which to make choices. In fact manpower planners introduce a considerable range of choice into their models.

For one thing, many skills that the neo-classical economist would distinguish as different, with varying degrees of substitutability in production, will not be distinguished at all in pragmatically defining the elements of an input-output matrix for manpower planning purposes. The effect is to assume perfect (infinite) elasticities of substitution among the skills classified together as against zero elasticities of substitution between skills put in different categories. The Tinbergen-Bos model* illustrates one extreme in this respect, with its categorization into just three educational attainment groups between which there is no substitution at all, but within each of which there is an implicit infinite elasticity of substitution. Usually the categorizations in manpower planning models are more numerous (especially when classified by occupations or sectors of the economy, but also to include types of schoolings); however, the sharp dichotomization of the within- and the between- category elasticities are not altered thereby. This simplifying technique is specified in the manpower columns of the tableau in row (3), referring to "treatment of demands for skills". It should be noted, however, that the basic principle of classification of factors into groups within which it suffices for a particular problem to assume perfect elasticity of substitution, whatever the elasticities of substitution between groups, is in no way peculiar to manpower and related models. The authors of the Report approach this way of looking at things in occasional comments concerning whether men with different amounts of schooling are "substitutive" or "complementary", and concerning some implications of complementarity both for manpower planning procedures and for methods in analyses of contributions of education to growth in national income. Their criticism (see, e. g. pages 9 and 42) of the conventional procedure of aggregating educational components of human capital using a perfect substitutability assumption instead of considering men (and women) with different amounts of schooling as separate kinds of inputs is, in my judgment, well taken. **On the other hand, the phrasing of

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* See Jan Tinbergen et al. (1965).

** I argued this point in particular in Part II of my paper on "Principles in the Valuation of Human Capital", presented at the 1967 meeting of the International Association for the Study of Income and Wealth. See Bowman (1968).

TABLE

	MANPOWER PLANNERS	CONVERGENCE	HUMAN-INVESTMENT THEORISTS
1. Core Models	Fixed-Coefficient Models Leontieff Input-output Matrices and "Quantitative" Planning. Aggregative Flow Models (Tinbergen and Bos).	(Dynamic Linear Programming).	Neo-Classical Models Aggregate Production Functions. Decision Theory. Capital Theory. Pareto Optimum.
2. Relation to Planning	Planning is Main Purpose Forecasting "Manpower Requirements": linked to general economic plans. Estimation of manpower and education bottlenecks. No benefit/cost comparisons.	Goal or criterion variable usually a function of national income or growth rate.	Planning a secondary or incidental. Planning of no interest to some, a main interest of others. Partial or project evaluations; not linked to general economic plans. Benefit/cost comparisons.
3. Treatment of Demands for Skills	"Requirements" estimation central. Inelastic demands. Zero elasticities of substitution among factors, at least in first approximation (but infinite elasticities within skill categories). Assumes that if variables are correctly specified and measured, solutions will be fully determined.	Demands for skills are functions of "technology" (and of final product mix). (Increases in physical capital probably raise demands for high-level skills).	Do not project demand shifts. Use of constant elasticity functions. Some models infinite demand elasticity in first approximation. Shadow pricing.
4. Treatment of Supplies of Skills	Supplies exogenously determined by "social" (private) demand, subject to quantitative constraints.		Theory of investment in human beings; skill supplies endogenously determined.
5. Relationships of skill demands and supplies	Supplies as possible constraints on realization of "requirements". Over- and under-supply a deviation from regression lines. Consistency criterion.		Supplies as response to anticipated demands. Interdependence; supply may in turn affect demand. Market equilibria.

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	MANPOWER PLANNERS	CONVERGENCE	HUMAN-INVESTMENT THEORISTS
6. Time perspectives	Forecasts for future target dates. Sometimes sequential input-output matrices for education.	Dynamic linear programming and related models.	Longitudinal. Point valuations of future income paths; adjustments of cross-section data for growth rates.
7. Treatment of Productivity	Changes in productivity treated as exogenous; taken into account by making downward adjustments in estimates of manpower requirements.		Education raises the quality of labour and hence its contribution to economic growth (productivity). Changes in productivity over-all leads to upward adjustments in projected life-income streams.
8. Perceptions of Loci and Timing of Learning	In schools and formal programs. Long lead times required for most specializations.		By experience as important as school. Schooling and learning at work complementary. Short lead times for most specializations given general education.
9. Perceptions of adult training and retraining	A stop-gap measure, needed because of poor prior planning.		Partially ameliorative for under-educated persons, but also a permanent feature of dynamic society.
10. Interpretations of job mobility	Numerous job shifts evidence of planning error.		Job shifts evidence of adaptability.
11. Basic educational orientations	Specialization of training. Fitting men to jobs.		Emphasis on learning to learn. Mutual adaptations of jobs and men.

that criticism as presented in the Report is such that it fails to show the basic generality of the argument, and its independence of fixed-coefficient accounting.*

Another route by which the fixed-coefficient models escape determinism is by their assumption that particular skill mixes are required for particular "levels of technology", the very essence of manpower planning consisting in provision of a skill mix that will satisfy the "requirements" of a projected higher level of technology (or of income) in the future. Furthermore, if "technology" is defined not by some over-all indicator (which has frequently been simply a per capita income measure or, rarely, some indicator of physical capital as a whole), but rather in detail, the specification of "skill requirements" for realization of a given economic plan becomes just one stage in an iteration procedure in which technologies are being juggled to reach national income goals or, if possible, to raise the feasible targets.** And if we turn all this around, as Yugoslavian planners have usually done, to ask what will be the effects of alternative human-resource-development policies (along with other actions) on the growth of national income, the basic logic of decision-making, and with it of opportunity costing, comes back into focus. This is a re-orientation that I miss in this Report.

Finally, a wide range of alternatives is opened up once allowance is made in an input-output, fixed-coefficient model for changes in the final-product mix. This seems so obvious on the face of things, I wonder that is has not received more attention in the argumentation about economic structures and factor substitutabilities, and the meanings of empirical evidence on these matters. The analysis by economic sectors presented in the Report is relevant, but implications of the differences among sectors for over-all manpower planning are not drawn. Moreover, the authors of the Report do not discuss the importance of variability and hence flexibility in product mix within major economic sectors. Is the omission of any such discussion one of the results of the initial orientation that stimulated the OECD work, including its self-evaluation? Evidently if the same per capita national income can be realized with quite varied mixes of final products, and if the production coefficients differ with the nature of the final product, this must have implications for the whole notion of estimating "manpower requirements".*** I leave the answer to this small puzzle in how men think to the writers of the Report, who have shown themselves to be open to examination of such matters.

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* Finis Welch has given special attention to the problem of determining which skill levels (measuring "skill" by schooling) should be distinguished as different in kind, which could be combined (given proper value weights) in a single classification within which there would be no major distortion in assuming perfect elasticities of substitution. His methodology is very different, however, relying as it does on marginal productivity analysis. See Welch (1970).

** This comes up at a number of places in the Report, though always incidentally; I miss a systematic analysis of what is involved. Thus (page 11) the authors of the Report refer to Layard's complementary assumption but fail to note that the phrase "as soon as the level of technology is fixed" is critical. As Layard uses the phrase, I would argue that it is also essentially untestable, since it is always possible to argue that seeming misfits are attributable to mis-specification. One can ask how far, in Layard's theoretical formulation, it is appropriate to speak of a "level" of technology, how far rather he is referring to kinds of technology and the mix of those kinds. Cross-country data present problems that are partially avoided when using longitudinal data for a particular country so far as this problem is concerned.

*** Men who start with fixed-coefficient models not merely as convenient first approximations in dealing with complex problems, but virtually as axioms defining the nature of economies have argued that findings of loose relationships between skill mixes and levels of national income (or rates of economic growth) merely reflect faulty data, poor specifications, and inadequate refinements. However, it is difficult to see how perfecting the data in detail, even if we then observed tight relationships between particular outputs and inputs, would yield unambiguous specifications of skill mix for the entire economy. Moreover, it is improbable that results would be so tidy, short of definitions that gave such results tautologically in the ways in which inputs and outputs were specified.

2. SUPPLIES OF SKILLS AND ADJUSTMENTS BETWEEN DEMANDS AND SUPPLIES

Three critical differences between manpower planners and human-investment economists that have already been noted in the first two rows of the table are their degrees of concentration on planning versus an analysis of economic systems, on central planning versus project evaluation, and on adherence to quantitative measures versus pricing (whether for planning or for explanatory analysis). Associated with these contrasts are marked differences in treatments of determinants of skill supplies and of problems of human resource allocation and utilization. By the same token, the two modes of thinking have led to quite different approaches to the meaning of "waste" and to quite different emphases in judging the success of the planning effort. The test of a good manpower plan will be its consistency ex ante and the accuracy of predictions viewed ex post - both in the context of a total economic plan. Waste and malutilization seem to be identified with unemployment or underemployment of a man's skills (though I have some difficulty with understanding manpower thinking on this one). Less concerned with over-all central planning at a detailed level, the human-investment theorist will apply less stringent tests of "consistency", but will insist on the incorporation of benefit/cost estimates (and critiques of them) in the development of the plan.

Several themes command our attention in this context. First, I shall comment on the treatment of determinants of skill supplies and the importance of insights derived from human-investment theory for the ways in which the nature and loci of learning are perceived. This has extreme importance to manpower planning, and I shall come back to it, in connection with uncertainty and flexibility, in the last section. Second, I will digress briefly to comment on a fallacy in interpretation of "evidence" that seems to stem from a mechanistic view of "shortage" and "waste" together with a neglect of attention to the determinants of skill supplies. A third discussion is concerned with the treatment of market adjustments between demands and supplies in the allocation and utilization of skills, and how this issue is handled. Finally, I go on to some remarks on how modes of thought have affected the treatment of "productivity" , views of job mobility, and of what is regarded as "fortunate" or the reverse in empirical findings such as those presented in this Report.

Treatment of the Determinants of Skill Supplies

It might be presumed that analysis of factors that determine supplies of men with various skills would be essential to intelligent manpower planning, and this indeed has been recognized. But the starting points of the fixed-coefficient and the human-investment models in approaching this aspect of planning have been very different.

The fixed-coefficient manpower models require, for assessment of the feasibility of realizing requirements projections, an analysis of constraints on prospective flows through the educational system. The bare bones of such an analysis concentrate simply on the logistics of the process, with special attention to teacher bottlenecks; this is essentially the Tinbergen-Correa model, though later applications have been more complex. Others have gone further, to take into account pressures of "social demands" and effects of catering to these demands for places in the system. "Social" demands in this particular semantics refer, of course, to private demands.* In either case, with or without consideration of "social demands", the factors determining skill supplies are treated as exogenous; there is no consideration of effects of anticipated returns on investments in schooling or, by implication, of economic demands of a society for qualified human resources.

In marked contrast, the human-investment theorist builds anticipated wage differentials into his explanatory models of individual behaviour with respect to schooling. Putting this another way, he has been concerned directly with comparisons of costs and benefits in the making of investment choices, whether he is using his model for the analysis of behaviour and market adjustment or for the assessment of societal benefits and costs associated with one or another educational policy and human resource flow. In a first approximation he evades some of the problems that are central to the manpower planner's approach by a preliminary assumption of infinitely elastic demands and/or (and either alternative will save him), a shift in demand over time sufficient to neutralize any depressing effect of increased numbers of college graduates (for example) on their earnings. The next step has been in a manpower direction, experimenting with dynamic linear programming and related devices to derive shadow-prices for the construction of expected benefit streams from investments on an extra-marginal scale. However, no matter what use he makes of manpower planning tools or elements in manpower planning models, the benefit/cost element remains central. And back of this, the related interpretation of economic processes incorporates determination of levels of investment in human resources as an endogenous variable in the system. Supplies of educated people are "explained" in part, at least, as responses to anticipated demands for their skills together with the costs of acquiring the education; government enters in as it reduces private costs by subsidy and as it may constrain access to some (or all) types of training.

The authors of the Report quite properly set aside the theoretical and empirical applications of investment theory in the study of determinants of supplies of educated persons; to include more than their brief remarks on this work (and its use of wage and price data) would have been to take on a second major task. However, they reiterate repeatedly the identification problem in using cross-country data to analyse relationships between education and income - a problem equally severe in aggregative analysis with longitudinal data for a given country. This problem is put neatly on page 154: "Whatever indicator may be used to measure the level of development, does it result from the level of education of the working population, or is this level of education a consequence of the level of development attained?" Evidently the answer must be both; this is a classic example of a problem calling for use of a simultaneous (or possibly recursive) system of equations. This, the authors of the Report did not do initially, despite references to "simultaneous" analysis. However, it is my understanding that they have since been experimenting with a recursive model suggested by Malinvaud.

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* Presumably this usage of the adjective "social" found its way into manpower parlance primarily as the expression of a belief that demands of individuals for education were predominantly non-economic.

The concentration of human-investment analysis on the parameters of educational investment decision, which includes examination of the implications of shapes of anticipated life-income streams, has supported an increasing awareness of and sophistication in analysing the nature and loci of education and training assessed in economic terms. Whereas the manpower planners have dealt primarily with training in schools or with formal programmes elsewhere, human-investment theory has brought a renewed emphasis not only on learning through experience (which was emphasized by Strumilin in his famous 1924 article), but on the conditions that foster such learning, and who incurs what part of the costs and the returns on "investments" in this sort of human-resource development. The quantitative importance of post-school learning and its complementarity with amount of schooling can depend in critical ways upon the institutional structuring of labour markets, however. Considerations such as these must be taken into account before the data presented in the Report can begin to be understood.

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A DIGRESSION ON THE REPORT AND THE NATURE OF EVIDENCE

Although the Report unquestionably had its reason for being concerned about manpower planning, its main content is descriptive of labour force patterns across nations and across levels of economic attainment. With occasional exceptions, I have chosen to omit comment on statistical methodology and the characteristics of the equations used*;

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* One error that is repeated at several points in a fallacious argument concerning selection of dependent variables and their inter-relationships must be noted, however. The authors set up the following in several places, but an example is on page 206 of the original manuscript. (I simplify to disregard their unnecessary conversion to percentages).

1. $\log(Ljk/L) = \log a_o + a_1 \log(Lj/L)$

2. $\log(Ljk/Lj) = \log b_o + b_1 \log(Lj/L)$

3. By virtue of the definitions of these terms, we have the identity:
$Ljk/Lj \equiv (Ljk/L)\,(L/Lj)$

and

4. $\log(Ljk/Lj) \equiv \log(Ljk/L) - \log(Lj/L).$

The authors of the Report then substitute the *equation* 1 in the *identity* 4, coming up with the bastard result:

5. $\log(Ljk/Lj) = \log a_o + (a_1 - 1)\log(Lj/L).$

But note that if the analysis is constrained to fulfill the conditions of the *identity* 4, it necessarily follows that b_o cannot be a *constant* as in equation 1. Instead it is necessarily a *variable*, and in fact is identical with $\log(Ljk/L)$. Similarly, the identity would require that $\log a_o$ be a *variable* = $\log(Ljk/Lj)$, and the coefficients a_1 and b_1 under these circumstances must be +1 and -1 respectively. I am not objecting to the *equations* 1 and 2, but it must be recognized that the Report does not use a *system* of equations that are specified to be mutually consistent.

these matters will almost certainly be well covered by other commentators. However, what the authors seem to regard as "evidence" on the important subject of substitutability between skills (different levels of embodied education) illustrate fallacies that call for comment because they recur in the work of many manpower requirements specialists.* A particularly unfortunate example is the statement on page 332 of the Report:

> "Barring then a few rare exceptions, graphic analysis cannot explain by substitution effects the mediocre correlations noted between the sectoral education coefficients and economic indicators. In other words, few indeed are the countries "overeducated" at university level which are "under-educated" at secondary level, and vice-versa".

There are at least two serious fallacies in this statement. First, if the data cannot "explain by substitution effects", neither do the data or the analysis support the contrary proposition - quite aside from the fact that a "few" countries make up a considerable proportion of a small sample. Second, the whole notion of what is over - and what is under-supply seems to be derived mechanistically from regressions. There is no criterion by which one alternative is compared with another under the relevant circumstances of a given country. For example, the abundance of human relative to other resources in Japan, and the associated low social cost of educating Japanese, finds no place in this analysis.

Elsewhere, authors of the Report appear to have based their conclusion that different levels of education are not "substitutive" on the observed fact that generally countries below the regression line on university education, for example, will be below it on secondary education also, and vice versa. But whatever the true situation with regard to skill substitutabilities may be, such a statistical test is not a valid one. It takes no account of the fact that factors explaining a high rate of attendance in universities may be closely associated with those explaining large proportions with secondary schooling. This slip is curious in view of the emphasis the authors put on "effects of supply as well as demand" in determining observed relationships between educational characteristics of men in one or another occupation (or economic sector) and a country's level of income.

Skill Allocation and Utilization

The sorting out of effects of educational supply versus manpower demand on the distribution of skills by occupations or sectors of employment is a task to which the authors of the Report devote many pages, and they have made a useful contribution in doing so. Nevertheless, despite the very large output of equations to explain statistically one or another aspect of the composition of thelabourforce, at no place did they even mention the possibilities of analysis that would take account of relative wage rates. The lack of an underlying analytical framework with respect to adjustment processes inlabourmarkets leaves the authors without a basis from which to predict or to interpret many of their observations. The high income-elasticity of proportions of better-educated people in sales occupations is a clear example of a pattern that should have been anticipated but that seemed to puzzle the authors. Even at the end of the documents, where the authors do introduce comments about using wage data in connection with the decision-theory models of determinants of investment in human beings, there is no hint of interest in considering experimentation with equations that would incorporate wage variables in analysis of processes of skill allocation, or examination of the effects of supplies of other resources on the economic soundness of further investments in the formation of human skills. The lack of empirical analysis utilizing wage data might be attributed to difficulties in obtaining such data and to the sheer magnitude and complexity of the analytical task. However, the lack of any discussion of this matter despite the elaboration of detail concerning labour force composition and allocation is not so easily dismissed. It becomes understandable only when seen as a reflection of the initial orientation to the fixed coefficient, manpower planning viewpoint. The disregard of allocative processes means also that the basic logic of planning, as an assessment of alternatives, tends to be lost from view.

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* The conclusions are not what is at issue. Indeed, I have already indicated my support for the authors' argument that men with different levels of education should probably be treated as separate kinds of "inputs" in analyses of contributions of education to income growth.

The Treatment of "Productivity"

The fixed-coefficient view seems to be associated quite naturally with what looks to the human-investment economist as a very odd, even if not an incorrect, way of looking at productivity. In the perspective of manpower-requirements forecasting, an anticipated rise in productivity is a datum of the problem, and if productivity increases fewer men (of any given skill category) will be "required" to meet the targets of a plan. The why's of the productivity increase are not considered; productivity change is taken as exogenous at least in the sense that it is treated as if it were independent of skills, and it reduces demands for skilled as well as unskilled workers. In sharp contrast, the human-investment theorist approaches productivity the other way around. Education raises the quality of labour, and hence its productivity. But if a larger proportion of educated people is a factor (with others) in explaining productivity increase, the realization of that higher productivity cannot be regarded as a reason for reducing estimated numbers demanded. Rather, the question becomes whether the increase in productivity is sufficient to match the cost of producing the skills. Back of these contrasting views we find substitution and factor-demand elasticities once again. If he adheres to his inelasticity assumptions, the conventional manpower planner will suppose that demand may shift substantially but will remain highly inelastic; a downward adjustment in projected numbers required will be important if his plans are not to lead to serious over-supply and unemployment (or grossly wasteful employment) of trained men. The human investment theorist, who would plan to leave more of the planning and decision-making to individuals in the first place, is more likely to assume comparatively elastic demands, with a greater flexibility in adaptation of the economic system to the mix of productive capacities available in the labour force. Such being the case, the increased productivity of better educated persons will be diffused through the system and there need be relatively little concern about serious over-supply of skill. From this perspective, the treating of proportions of all workers who are engaged in a particular occupation (and also have a particular amount of schooling) as a dependent variable in equations in which the one and only independent variable is national income per worker seems a reversal. That way of setting up the equations is a natural enough outcome of the manpower orientation and a reasonable enough procedure given the purpose of testing the assumptions commonly used in estimating manpower "requirements", however. My sense of logical frustration only becomes severe when I read the authors' comment on an equation the dependent variable of which was proportion of the labour force with more than 8 years of schooling and in major occupation group 7/8.*

> "However, bearing in mind the broad scope of this occupation category . . . a high elasticity for the "more than eight years' schooling" level merely reflects the rapidly rising need for formal education, a need which rises with productivity, as well as the need for more foremen, overseers, etc." (italics mine).

Here we have a sort of back-twist. The rise in the "need" is because "productivity" *ex-post*, as observed in the empirical data, is higher, and higher *ex-post* productivity is virtually synonymous with higher per capita income (level of technology) which will generally "require" a higher proportion of better-educated manpower. But the estimated manpower "requirements" for realization of the associated national income will be lower than they would be otherwise on account of the rise in productivity. In practice, manpower requirements projections are extremely sensitive to projected changes in productivity, as several studies have demonstrated.**

Meanwhile, it must be emphasized, the human-investment theorist has not contributed much of anything to the solution of the problem of anticipating future demands for skills. This is just because he would like to see the question turned around, to ask what would be the productivity effects of increasing outputs of one or another sort of school graduates, in various numbers. But he has no substitute technique for the projection of demand shifts.

Attitude toward Mobility

Seven years ago at an international meeting the contrast between the perceptions of job mobility among central planners and market economists was brought into sharp relief. With one or two exceptions, the men from countries characterized by detailed central planning viewed job mobility as evidence of the defectiveness of manpower plans or of their implementation. If there is a logic in this, it is clearly derived from the fixed coefficient mode of thought; high job mobility of individuals under such circumstances would be likely to entail serious under-utilization of some skills. Others at the meetings, whether from America or Western Europe, were of quite another opinion; indeed, it was their matter-of-fact remarks about job mobility and its evidence for the adaptability of individuals and the flexibility of the economy that brought out the expression of the opposite interpretation among colleagues from the East. I was considerably surprised, however, to see how views of mobility are expressed and interpreted by the authors of the present report. On page 341, they set up a deliberately exaggerated dichotomy:

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* Occupation group 7/8 refers to "craftsmen, production workers and labourers".

** Particularly relevant is a recent study for Greece by George Psacharopolous (1968). His research includes tests of the effects of introducing alternative sets of coefficients using input-output matrices from other countries, as well as tests for the sensitivity of projected manpower requirements to projected rates of increase in productivity.

> "When all is said and done, the great dilemma besetting the relations between occupational categories and levels of education may be reduced to a discussion of the "specialization" or "mobility" of the products of the educational system. The planners advocating "specialization" believe that they can fairly accurately forecast the requirements in each occupational category, and that their only problem is to find *the* level of education best *associated* with that category.
>
> Contrariwise, the advocates of mobility at any cost are drawn from among those who are sceptical as to the possibility as to the possibility of reliable manpower forecasting."

The first paragraph of this quotation states one point of view clearly enough, and we can leave it at that. The second paragraph, from which I have reproduced only the first sentence, would be a satisfactory statement of the opposite point of view, were it not for the quoted opening sentence. It is extraordinary, for one thing, that the sentence in which the phrase "at any cost" occurs is that pertaining to advocation of mobility; systematic counting of costs has hardly characterized the fixed-coefficient manpower planning models, whereas just such cost accounting has been a key element in human-investment economics, which has generally come down also on the side of flexibility (though it does not necessarily do so). But also the quoted sentence attributes to the critic of conventional manpower planning a view that might better be called the manpower planner's nightmare than the decision economist's reason for advocating education for "mobility" or adaptability. Even if future demand can be accurately predicted for any given target date, there is the inexorable fact that men live their lives through many target dates, and over time specialized skills become obsolete. The most costly human investments under such circumstances are likely to be investments in training for narrowly defined tasks. This is an important matter to which I shall return.

Following this, in the version from which I am working the Report went on to distinguish the approaches of "economists" and of "sociologists" in terms that convinced me the sociologists must be the best economists after all (p. 342).

> "In the hands of economists, conscious of the growing specialization of *jobs*, and primarily concerned with avoiding unemployment in any form. Such education planning would produce only "specialists" incapable of forming any general ideas. In the view of the sociologists haunted by the problem of reconciling the free will of the individual and long-term social justice, it would tend to produce people "unusable" for the immense majority of industrial jobs".

This seems a strange theory of the causes of unemployment, althouth I recognize some old themes replayed here along with views about the sources of concern about unemployment of primary school leavers in Africa, or secondary-school graduates in India, or lawyers in Greece. And as for the "sociologists", it would appear that they may be quite good neo-classical economists, that they believe a man's preferences for how he spends his time may be as important as his preferences in how he spends his money, that they assume that he pays at least some heed to the relationship between his schooling and his anticipated future career prospects, and that general schooling is not inimical to the performance of industrial jobs.

These comments bring me to one of the most characteristic contrasts between the manpower and the decision-theory modes of thought. I refer to reactions to empirical findings of loose relationships between levels of national income or rates of growth in incomes and the educational composition of thelabourforce (or of particular segments of it). Again and again one encounters remarks from manpower planners to the effect: "Unfortunately, the correlations are very low . . . " or "Fortunately, the correlations between proportions in technical high-level jobs and . . . are high", or "Hopefully, further research, with more refined data, will enable us to identify these relationships much more tightly". In these statements hopefulness relates to the ease with which forecasting of manpower requirements can be carried out - but nothing to do with what is fortunate or unfortunate for people or a society. The human-investment economist who traces his ancestry more to Adam Smith than to the mercantilists will react in the opposite way. "Fortunately, the observed associations are loose enough to ensure some give or flexibility in economic adjustments".

3. THE LOGIC OF EDUCATIONAL PLANNING FOR DYNAMIC DEVELOPMENT

Economic development is a dynamic process, and no model or technique for educational and manpower planning that waives consideration of what fosters and what impedes technological advance and the diffusion of improved practices* will long prove satisfactory. Yet neither the conventional manpower-planning procedures nor the applications of human-investment theory to analysis of policy alternatives have incorporated consideration of the basic dynamics of the processes by which development occurs. Evidently, analysis of dynamic processes is peculiarly difficult. This is a primary reason why the state of our theories of economic development continues to be so unsatisfactory, and provides so little help to the would-be manpower or educational planner. But we need not wait for a full-fledged theory of dynamic development before taking into account some of the evident implications of the dynamics of change, implications of critical importance to strategies in human resource formation and educational policy. Two of these critical implications are: (1) Things will change substantially over the working life of any individual, assuming economic development to continue, and no single target date represents "the future demand" for skills of a cohort currently being educated. (2) In the planner's projective view of the future, and of how alternative lines of action may affect that future, the only certainty must be certainty of change - unless, of course, his policies operate to block development instead of fostering it. This will continue to be the situation whatever we may know or learn in the reasonably near future about the nature of the dynamics of development. But I cannot share the view that seems to be held by the authors of the Report, and shared by many others, that this is a "negative" conclusion or a defeatist stance. Though I hope that we will substantially enlarge our understanding in these matters, and am committed to such an endeavour, I am not at all sorry we are unlikely to become omniscient, or that the world is unlikely to become the kind of place in which history is so tidily repetitive as to provide men with the basis for firm and detailed predictions.

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* Including organizational innovations and techniques for decision-making at a micro level.

Perspectives in Time

It is often supposed that the manpower planners look into the future, whereas human-investment theorists and social benefit/cost estimators do not. This is a misleading perception. Both look into the future, but in different ways; and both are inadequate in this respect.

The manpower planner's time perspective is a particular target date in the future. He may trace flows through the schools in the interim, with the range of physical possibilities and the bottlenecks that will be encountered. Presumably, also, he will modify projections of both "manpower requirements" and supply prospects for a particular date as that date approaches, and he will at the same time add on new target dates; in this sense he is considering a sequence of future dates, to be sure. However, there is nothing in his procedures that refers to entire spans of working lives of individuals who are being educated or trained (or who are being shunted into the labourforce with very little education or training prospects). In effect, he is planning not for the development of productive, let alone adaptive, people, but for the supplying of "skills".

The human-investment economist looks into the future as a time path of prospective earnings or productive potentials associated with one kind or level of education versus another. Furthermore, if he is sophisticated in his understanding and application of his constructs, his view of that time path will include the extent and effects of post-school training and learning both to counter obsolescence and to further upgrade productive capacities.

I am not suggesting that his treatment of the obsolescence problem has been adequate, for such definitely is not the case; but at least obsolescence can find a place in his model. It finds a place because the human-investment economist starts from individuals as his units of observation rather than from target date skill mixes, and benefit/cost accounting takes into account the differential incidence of unemployment over a man's life as unemployment may be associated with levels and kinds of schooling.

The first approximations to projections of time paths of future earnings were merely simple cross-section current age-earnings profiles (with or without "ability" adjustments) treated as if they were longitudinal projections for today's cohorts of young people. The more usual procedure recently is to adjust the cross-section data by application of an assumed rate of growth in productivity. The theoretical basis for such an adjustment matters very little when the purpose of the analysis is merely to study individual decisions and determinants of skill supplies. However, when these models are extended (with appropriate adaptations) to benefit/cost accounting at more aggregative levels the reasons for the projected productivity increases become more important. So far as I am aware, the rationale of adjustments for projected rates of growth in productivity has not been elaborated, but basically such adjustments amount to predictions that the interactive effects of human resource development, physical capital formation, and advances in knowledge and technology generally will be such as to raise the productivity of graduates of a given level (or kind) of schooling in parallel with rates of growth in productivity generally. Despite my earlier comments concerning treatment of productivity in manpower planning as contrasted to human-investment models, they converge on much the same pragmatic grounds here.

Continuing, for the moment, with a single cohort, even though public policy decisions pertaining to education will normally extend over future cohorts as well, there is still the question: what about the effects of large versus small changes in numbers on prospective productive contributions and life-earnings paths? In central planning (or any planning of activities that will have large scale impact) this problem can become inextricably bound up with projections of future earnings paths. As I remarked earlier, there is no tidy answer, although there is the useful technique of testing the sensitivity of benefit/cost findings to a range of assumptions concerning demand elasticities. Particularly important, in this context, is the degree of job adaptability (potential for job mobility) with one kind of training versus another; demand elasticities for the services of an individual will be greater the wider the range of skills he can claim or, especially, the greater the speed with which he can acquire new ones.

Finally, the time horizons of educational planning in a human-investment framework are compounded of the horizon in numbers of cohorts considered and the working-life spans of those cohorts. At the extreme, the time horizon could be said to be the sum of typical working-life span and numbers of cohorts within the planner's purview; this sum would take the last (youngest) cohort through its working years. However, even at very modest discount rates the present value of income anticipated with virtual certainty for a remote future date will be very small, however large that anticipated income may be - quite aside from the fact that the more remote the future the more uncertain the anticipations. In practice, therefore, the values estimated for the most distant horizons will have little effect on the benefit/cost outcomes.*

First Moves and Relevant Future Parameters

A sound strategy of planning under uncertainty will be a selective strategy, economizing on the elaboration of projective estimates, but taking careful stock of ways in which actions taken now - first moves - will affect the scope of alternatives open in the future; that is, it will concentrate particularly, so far as future prospects are concerned, on how present actions will affect parameters conditioning future choices. This approach to planning has relevance for educational and manpower planning in several ways, but I limit comments here to just two.

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* In dynamic linear-programming models that use present-value measures in their "objective functions", terminal dates are normally taken considerably short of a working-life horizon even for today's cohort. Such models avoid the closure effect of terminal dates by specifying, for example, that "present values" for successive dates over the planning period cannot decline. See, for example, Irma Adelman (1966) and Samuel Bowles (1965, 1969).

First, it specifies a rule of very general applicability to substantive decisions about how young people should be educated and to what levels. Phrased as a criterion question: how will what we plan on their behalf affect their scope for choice in the future ? This is another way of putting the argument for flexibility and emphasis upon learning to learn as the heart of education for dynamic change. It is both a pragmatic and a philosophic proposition. If individuals are regarded simply as pawns on a chessboard, the scope for choice is a scope for the chess player (manpower allocator ?) to move them around. But in addition, some of us at least consider the enlargement of the scope of choice open to individuals to be a desirable goal in itself. Fortunately for society (not just for planners) a strategy to foster economic growth and the criterion of enlargement of individual choice are mutually supportive when seen in this light*. Five years ago, in our essay on "Theoretical Considerations in Educational Planning", C.A. Anderson and I criticized the conventional manpower approach for its disregard of these considerations, and I see no reason to modify those remarks today**:

> "The model has several further implications that should be examined. It puts quite out of consideration any significant market adjustments to re-allocate available manpower among uses, and automatically diverts its practitioners from considering long-term strategies to facilitate more efficient short-term adjustments in manpower utilization. It slurs over awkward problems of future obsolescence of the skills of today's output of new manpower and evades the question of whether the proposed programs of training may increase that obsolescence".

The logic of the "first moves" theory of decision-making under uncertainty is relevant, secondly, to the planning process itself. Planning can be an omnivorous consumer of human resources, and it is all too easy to multiply planning activities with results that may be impressive in paper work and computer output, but less and less discriminating and thoughtful. The "first moves" analysis of decision-making, though initially developed in application to decision-making in large business corporations, is equally applicable to educational- and manpower-planning activities of public agencies. It was partly as an application of that approach to decision-making under uncertainty that Anderson and I challenged the propensity of many devotees of detailed central planning to insist that long lead times are needed on all planning fronts. That argument is closely associated with other characteristics of the manpower-planning mode of thought. Again I reproduce our discussion, this time in more detail***.

> "Proponents of detailed manpower planning usually argue, virtually as an axiom though with occasional illustrations, that a long lead time is needed and that manpower forecasting for educational planning purposes must therefore have medium to long time horizons. Further, they assume that students (or their parents) are unwise choosers and forecasters and that central authorities must determine (directly or indirectly) the numbers of places in various schools and curricula without regard to prospective students' demands. Deviation from this position is seen as a concession to other, "social" educational goals."

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* Anderson and Bowman (1964) p. 24.

** See Franco Modigliani and Kalman J. Cohen (1958).

*** Anderson and Bowman (1964) pp. 22-23.

Pushing back of all these characteristics, we can begin to construct the implicit theoretical framework at the core of the detailed manpower approach to educational planning.

1) The first assumption has already been explicity identified and reiterated, the assumption of ex ante near-zero elasticities of demand for skills (ex ante near-zero skill substitutabilities).

2) The period of specialized training in several of the more critical skills is taken bo be long (irrespective of the length of prior general education). It is no accident that proponents of detailed, long-term manpower planning refer so often to physicians in illustration of this point. No one assumes that the training period for medicine is typical, though no one would disagree that medical education requires a relatively long lead time. Medicine is also less problematic on the requirements-forecasting side than many other high-level specialities - at least if one does not raise questions about the "need" for many fully-fledged physicians at all. In the usual case the future requirements for physicians are in large part derived from demographic predictions, their payment is often socialized, and the demand for doctors is comparatively unaffected by changing production technologies.

3) It is explicitly asserted that a long lead time is required to provide the facilities in plant and personnel needed to train the new cohorts of manpower. This proposition, if true, adds to the time lapse involved in (2), provided that (4) is also applicable.

4) Production coefficients in the formation of each type of manpower are taken to be highly fixed. In part this is just a particular facet of the assumption of inelastic demand for human skills: inelastic skill substitutabilities among teachers in various curricula and also between teaching and other activities. However, rigid educational production functions would imply also inflexibility in pupil/teacher ratios, in per student allowance of classroom and laboratory space, and so on. Plans often stipulate adjustments on this score, however, especially with regard to teacher/pupil ratios and teacher qualifications at the lower levels of school in underdeveloped countries. The plans almost always fail to give serious attention to the possibilities of substitution between skill acquisition in schools and by other means, or the limits of such substitution.

5) It is assumed that the pace of change in manpower requirements is both rapid and irregular and/or that there are critical educational decisions entailing large investments that are both indivisible ans specialized in their educational uses. Assuming manpower-production goals as predominant, either of these situations will call for unevenly spaced large decisions with relatively long planning horizons. Unless one, or both, of these conditions prevails, the relevance of points (3) and (4) to the argument for detailed manpower forecasting well into the future is decidedly weakened. An even pace of change would allow for feedback adjustments at the margins at which decisions must be made. Hence, there would be little need for looking beyond the period of specialized training itself. Furthermore, if skill demands change relatively smoothly, the presumption against heeding student choices (as a major guide for expanding educational programs) is greatly weakened even if it is not shattered. Emphasis upon educational decisions that entail large and indivisible investments is encouraged by two additional circumstances: the tendency to set manpower targets at intervals of several years ahead; and the association of manpower planning with centralized educational planning".

A FEW CLOSING REMARKS

Finally, I hazard a few brief words concerning priorities and prospects for progress in the understanding of relationships between human-resource development and economic advance, along with coordinate improvements in educational and manpower planning.

So far as positive economics is concerned, almost certainly we will see more econometrically sophisticated analyses of the kinds of relationships with which the Report was concerned, using not only the data now available but better and more extensive data that are sure to materialize in the near future. This will mean, among other things, a greater sophistication in the construction of models for empirical testing, and the use of simultaneous and of recursive equation systems. Probably it is not too optimistic to predict that studies of substitution elasticities based on use of wage data will be extended, and that the quantitative models that have come out of the workshops of those most involved in manpower planning will be placed beside the work that has been and will be done by other economists, working from price and value theory.

I anticipate also some important break-throughs in the attempts to determine just *how* education contributes to productivity, under what circumstances. This means, among other things, more incisive analysis of the extent and nature of substitution and complementarity among kinds and levels of skills and between these and physical capital. Beginnings of this development have emerged independently in work by D. P. Chaudhri in India and Finis Welch in the United States. Increasingly attention is being directed to the identification of adaptive and innovative versus more conventional sorts of "skills" as functions of education. In these studies, emphasis is on the role of education in *change*.

So far as the future in educational and manpower planning is concerned, it is my hope - though not yet, I fear, my prediction - that the basic logic of decision-making under uncertainty will come to play a greater part in the way planners think and what they attempt to do. This calls for a more discriminating approach to decision problems.

And finally, I am impelled to reiterate the words with which Anderson and I closed our earlier paper*:

> "Planning for a dynamic future requires planning for flexibility, both in the human resources we create and in the scope for future revision of plans. It must be evident also that however skilled the planner-technicians, most important of all is wise men - wise enough not only to plan for others but also to plan so as to encourage others to plan for themselves, whether in a socialistic state or the welfare state that is the United States. In the end, that might prove to be the important guide to educational planning even when economic development is the sole goal. It is assuredly essential if the non-measurables are to be given adequate scope".

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* Anderson and Bowman (1964) p. 45.

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COMMENTS ON OECD's "OCCUPATIONAL AND EDUCATIONAL STRUCTURES OF THE LABOUR FORCE AND LEVELS OF ECONOMIC DEVELOPMENT - POSSIBILITIES AND LIMITATIONS OF AN INTERNATIONAL COMPARISON APPROACH (OECD, DAS/EID/69.16)

by

Mark Blaug

The purpose of this book is to answer two questions: (1) are there "world manpower growth paths", that is, definite patterns in the occupational and educational composition of the labour force of an economy which depend uniquely on output per worker, or, possibly, capital per worker; (2) and, if so, what do these look like and how can they be used for purposes of forecasting the future demand for different types of manpower ? I think it would be fair to summarize the findings of this study by saying that it answers question (1) by a "yes" so severely qualified as to become almost a "no" (see pp. 60, 150, 248, 262, 268, 284, 307, 310, 337, 382, 383), and that it never in fact supplies any clearcut answer to question (2).

What conditions have to be met to validate existence of "world manpower growth paths", such that poor countries could plan their future skill requirements by imitating richer countries ? In the extreme case, the answer is simple: no substitutability either in production or in consumption.

Spelling it out: all products would have to be produced with identical production functions throughout the world and these would all have to be fixed-coefficient production functions (fixed capital-labour ratios, fixed occupational coefficients, fixed educational coefficients, *et cetera*); all products would have to be consumed with identical consumption functions throughout the world and the aggregate consumption function would have to correspond to identical micro-patterns of consumption demand, otherwise variations in the composition of total output would reimpose the possibilities of substitution in production. In addition, technical progress in both production and consumption would have to be "neutral", that is, leave the *ratios* of different inputs and outputs that enter into production and the *ratios* of different products that enter into consumption unaffected; the same technical knowledge would also have to be freely available everywhere, or acquireable at the same costs.

Alternatively, all products might be produced with identical variable-coefficient production functions throughout the world but identical relative factor endowments and hence identical relative factor prices would leave all countries operating with identical capital-labour ratios and with identical occupational and educational coefficients. This case requires additional conditions, however: since a production function relates the maximum quantity of some exactly specified output to the quantity employed of some set of exactly specified inputs in a given long period, we must be sure that all countries are operating on the boundaries of their production functions; in other words, the condition is that all entrepreneurs maximize profits and that there are no differences in the quality of entrepreneurship in different countries. We also require now that all production functions are linear and homogeneous (although not necessarily Cobb-Douglas in form) and, once again, that technical progress is neutral. Furthermore, we require unit-income and unit-price elasticities of demand for all products and, as before, identical saving propensities and, by the way, identical import propensities and identical "public spending propensities". We might add that we also need identical labour force participation rates, identical educational participation rates, identical age and family size distributions of the population, and so on and so on. The implications of the extreme case are now self-evident: in order to observe "world manpower growth paths", in the simple sense of the term, all countries must be identical in all respects except for (i) absolute size and (ii) total-factor-productivity.

Clearly, we will never observe this extreme case in the real world. Casual inspection suggests that the extreme case is not even closely approximated. Nevertheless, the question is: how close do we actually get to it ? The answer is an empirical one but, since it runs in terms of probabilities, judgement will be required in the final analysis to tell us whether we have come close enough. Close enough for what ? It all depends on the purpose of the inquiry. If we are trying to explain how the skill mix of countries changes in the process of economic development, any answer will do: coming close means an end to our investigation; not coming very close means a further search for new variables with greater explanatory power. If we are trying to improve the art of manpower forecasting, however, not coming very close may mean that the whole notion of basing educational planning on international comparisons must be dismissed as a blind alley. If the feasible paths of manpower development are very wide, the question of the optimum skill mix of a labour force must be faced anew, perhaps with different tools and modes of thinking than have so far characterized the international comparative approach. To express it in other language, if given levels of economic development are not associated with a unique set of occupational and educational coefficients, all the single-equation estimates of this study and others like it are subject to simultaneous equation bias: we are testing the reduced forms of what is in effect a series of demand and supply equations (see p. 24).

As a case in point, consider the suggestion in this study (p. 38) of relating differences in the occupational and educational coefficients of different countries to variations in their wage and salary structures. In a paper circulated last year, Samuel Bowles did just that with respect to the educational coefficients; distinguishing three types of labour (those with less than 8 years of schooling; those with 8-12 years of schooling; and those with 12 or more years of schooling), he ran a cross-section regression (data for 12 countries, mostly around 1960) for three pairs of relative earnings on the corresponding pairs of relative labour inputs*. On the assumption that the aggregate production function of countries conforms to the CES (constant elasticity of substitution) production function, his results furnished estimates of the partial elasticities of substitution between the three types of labour. All the elasticities were significantly higher than three at the 99% level of significance, which implies considerable substitutability between people with these three levels of education. For example, the results suggest that a 1% change in the earnings of those who have at least completed primary school relative to those who have attended secondary school leads to a 12% change in the ratios in which these two types of labour are employed.

After making allowances for errors in measurement, unemployment, differences in the commodity composition of total output, and after checking his results against time series for the United States, Bowles concluded that demand elasticities for educated labour are indeed very high and, hence, that the assumption of constant relative earnings of labour in the analysis of planning problems is an adequate working generalization. No doubt, these results are subject to considerable qualifications: nothing is said about occupations, nor about the aggregation problem on the production side**. Nevertheless, they demonstrate the feasibility of this type of research. Data on wages and salaries cross-classified by educational attainment, and in some cases age and occupation, are now available for 22 countries (USA, Canada, United Kingdom, Denmark, The Netherlands, Belgium, France, Greece, Uganda, Kenya, Nigeria, Zambia, Israel, India, The Philippines, Japan, Hawaii, Mexico, Puerto Rico, Colombia, Chile and Venezuela), a number smaller than the 52 countries analysed in this study, to be sure, but one large enough to permit meaningful statistical analysis. One can only express the hope that the OECD, with its superior resources for raising data, will undertake this work.

The OECD study before us marks a great advance, in both the volume of data and in the interpretation of results, over earlier studies, such as those of Horowitz and Layard. In some respects, however, it marks a step backwards from Layard who explicitly raised the question of the use to which his results could be put by manpower forecasters. The OECD study mentions the problem of converting cross-section into time-series results (p. 25) but, apart from this, offers little guidance to policy makers (but see p. 382). One unresolved issue is: when we successfully fit an occupational-coefficient equation like:

$$\log \frac{L_{ij}}{L_i} = a + b \quad \log \frac{X_i}{L_i}$$

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* S. Bowles, "The Aggregation of Labor Inputs in the Study of Growth and Planning: Experiments with a Two Level CES Function", Economic Development Report No. 122, Project for Quantitative Research in Economic Development, Center for International Affairs, Harvard University, Cambridge, Mass., 1968.

** As the OECD study thinks nothing of estimating the production function of sectors of the economy, it is worth noting that production functions refer to homogeneous outputs and that the output of, say, "manufacturing" is far from homogeneous. The estimated parameters of an aggregate production function, whether aggregated at the sector level or at the level of the whole economy, are in fact arbitrarily weighted averages of the micro-production functions of individual industries. The only case in which the weights are not arbitrary is the case of perfect competition ruling everywhere, the weights themselves being the relative prices of factors. All this is to say that estimates of aggregate production functions are extremely difficult to interpret and must always be taken with a pinch of salt.

are we telling planners to have regard to the regression line or to the b-coefficient ? Suppose Ruritania falls below the line. Do we advise Ruritanian planners to maintain the ratio L_{ij}/X_i at the value b, or to increase the ratio as soon as possible until it reaches the average ratio for a country with that level of X_i/L_i. In short, should planners care only about the growth rates of labour in different occupations and educational categories in relation to the *growth* rates of output per man, or about the *absolute* levels of all these variables ?

Layard opts for the first of these two considerations and in so doing he is in good company with Harbison, Tinbergen, and other practitioners of the manpower-forecasting approach. But so long as there is even the slightest suspicion that educated manpower is often malutilized from the standpoint of productive efficiency, stocks are just as important as flows: we have to achieve optimum stocks of manpower in relation to levels of output, not just optimum flows of manpower relative to rates of growth of output. And so, I cannot help wondering: what would the OECD study have recommended for planning purposes if all the R^2's had approached unity and if all the standard errors had approached zero ?

A great many of OECD's results are difficult to interpret because they do not correspond to any recognizable economic theory of how the relevant variables are related. Take, for example, the continual reliance on labour productivity as the independent variable. Apparently, the notion is that employers or planners try to maximize output per worker, or, at any regard, regard output per worker as a critical variable. But business firms care only about total-factor-productivity: only by optimizing output per unit of all inputs can firms minimize costs per unit of output and thus maximize profits. As for planners, maximizing output per workers only makes sense if capital is free. Now it is true that output per work or the average productivity of labour is easy to measure, while total-factor-productivity involves the difficult task of measuring capital. But there is nothing in economic theory that suggests that labour productivity is a good proxy for total-factor-productivity. A cross-section comparison would almost certainly reveal wide discrepancies between the two and, as is well known, time series analysis on the level of individual industries indeed reveals substantial divergencies.

The OECD study, to be sure, shows a very high correlation across entire economies between gross capital formation (the cumulative sum of investment over the previous seven years) per worker and output per worker. But the last seven years of investment in the entire economy is no substitute for a weighted capital input in the productive process of an industry or even a sector. I can see no reason why output per unweighted labour input in a sector should bear any relationship to the occupational or educational distribution of the labour force in that sector, not even if investment is of the putty-clay instead of the putty-putty type. Hence, I regard the few meaningful results which the OECD study did produce as nearly miraculous. I can only account for them with the cynical argument that all economic variables are so highly intercorrelated that regression of any variable on any other always yields a pattern of some kind.

3

THE ELASTICITIES OF THE OECD STUDY AS PARAMETERS OF LOG-LINEAR MODELS

by

Jef Maton

In the presentation of its results, this OECD-study departs from the familiar procedure: instead of cutting out their best shots, framing them and suggesting in which art gallery they would suit best, the authors have presented somewhat indiscriminately all results obtained. Although the latter method is justified in its own right, readers more accustomed to the former approach may ask themselves the question: how do the results tie together and how do they fit in with the existing knowledge on the subject matter concerned. This paper tries to give a partial answer to this question.

In order to facilitate the discussion the 15 major sets of regression equations were brought together in a Synoptic Table. It should be understood that all variables presented in the Table are in log-linear form. The indication "log" and the constant terms were omitted for the sake of simplicity. The endogenous and exogenous variables appearing in the regression equations concern production, X, labour force, L, capital, K, demand and supply of workers in specific occupational or skill groups, L_j^d and L_j^s, demand and supply of workers with a specific educational background, L_k^d and L_k^s.

1. GENERAL EQUILIBRIUM MODELS IN LOG-LINEAR FORM AS FRAME OF REFERENCE

The variables concerned are linked together through multiple relations and circular interdependencies. The OECD-study has expressed those interrelationships under the form of equations and treated each equation individually. Since the individual equations express circular relationships between a limited number of economic variables, one can expect them to be derived from some or other general equilibrium model. In the following paragraphs an attempt will be made to formulate some appropriate models as a frame of reference. Subsequently, equations and variables will be eliminated until the models are reduced to single equations corresponding to specific regressions equations of the study under review. This exercise will enable us: first, to picture the more general framework from which the equations are drawn; second, to compare the approach followed in this study with alternative approaches followed in other studies; third, to throw light on the implicit assumptions involved.

The structure of the general model, we intend to construct, should cope with the particular features of the OECD-study. Two of those seem essential. First, all input-output relations are in log-linear form. Accordingly, the input-output relations in the general should also be in log-linear form. The log-linear universe of constant elasticities holds the mean between the Leontief universe of fixed coefficients and the neo-classical universe of perfect factor substitutability. One can expect, therefore, that the model will be composed of linear and neo-classical elements. Second, some of the input-output relations in the OECD-study concern the process of skill acquisition and explain how educational inputs are converted into skills. The model should, therefore, have a number of structural equations referring to this particular type of production process.

As mentionned in the foregoing paragraph, log-linear models find themselves between the Leontief and neo-classical universe. Our starting-point, therefore, will be the linear and neo-classical models, as they were presented in the standard work of Dorfman, Samuelson and Solow.* We will extend this models so as to have a number of structural equations explicitly referring to the production of skills. In a following step, the input-output relations will be made log-linear.

Let vector l' represent the resource inputs $\{L_1, L_2, \dots, L_{n-1}, L_n\}$, whereby $L_1, L_2, \dots L_n$ represent the various skill categories. Let vector x' represent the sectoral outputs $\{X_i\}$, i ranging from 1 to m. Vector w' will indicate prices, $\{W_1, \dots, W_n\}$, of resources, $L_1, \dots, L_n$, and p' the prices, $\{P_1, \dots, P_m\}$, of outputs, X_i. Leaving, for the time being, the educational inputs out of consideration the linear model can be written as

$$l^d = Ax^s \quad \text{(LA. 1)}$$

$$x^d = F(p, w) \quad \text{(LA. 2)}$$

$$l^s = F(p, w) \quad \text{(LA. 3)}$$

$$l^d = l^s \quad \text{(LA. 4)}$$

$$x^s = x^d \quad \text{(LA. 5)}$$

$$w'A = p' \quad \text{(LA. 6)}$$

The number of equations equals 3m + 3n. The unknowns add up to the same total: n factor services demanded, n factor services supplied, n factor prices, m products demanded, m products supplied and m output prices.

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* R. Dorfman, P. Samuelson and R. Solow: Linear Programming and Economic Analysis, 1958, Chapter 13.

The equations (LA. 1) are the demand equations for occupational skills. The sets of equations (LA. 2) and (LA. 3) form the demand equations for outputs and the supply equations for resources, respectively. It is a general rule to have the prices w and p as explanatory variables in both sets of equations, inter alia, because those prices do not appear in the set (LA. 1). Equations (LA. 4) and (LA. 5) state that the markets of resources and commodities must be cleared, which clearing process determines the equilibrium prices p and w. Finally, equations (LA. 6) state that the unit price of each output must equal its unit costs and determine the relation between the factor and commodity prices.

The keystone of this model is the technological matrix A, whose elements form the structural coefficients of the demand equations (LA. 1). Two important points should be made with respect to this matrix. First, in the linear model under discussion its elements are constant and given. Second, it can be viewed as a set of production functions transforming skill inputs into sectoral products. Those production functions can be written as*

$$1 = F(a_{11}, a_{21}, \dots, a_{n1})$$

$$1 = F(a_{12}, a_{22}, \dots, a_{n2})$$

$$\dots\dots\dots\dots\dots\dots\dots$$

$$1 = F(a_{1m}, a_{2m}, \dots, a_{nm})$$

or

$$X_1 = \min\left(\frac{L_{11}}{a_{11}}, \frac{L_{21}}{a_{21}}, \dots, \frac{L_{n1}}{a_{n1}}\right)$$

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* We write first the production functions as

$$X_1 = F(L_{11}, L_{21}, \dots, L_{n1})$$

$$X_2 = F(L_{12}, L_{22}, \dots, L_{n2})$$

$$\dots\dots\dots\dots\dots\dots\dots$$

$$X_m = F(L_{m1}, L_{m2}, \dots, L_{mn})$$

Dividing the first row by X_1, the second by X_2, etc. gives

$$1 = F\left(\frac{L_{11}}{X_1}, \frac{L_{21}}{X_2}, \dots, \frac{L_{n1}}{X_1}\right)$$

$$1 = F\left(\frac{L_{12}}{X_2}, \frac{L_{22}}{X_2}, \dots, \frac{L_{n2}}{X_2}\right)$$

$$\dots\dots\dots\dots\dots\dots\dots$$

$$1 = F\left(\frac{L_{1m}}{X_m}, \frac{L_{2m}}{X_m}, \dots, \frac{L_{nm}}{X_m}\right)$$

which is equal to

$$1 = F(a_{11}, a_{21}, \dots, a_{n1})$$

$$1 = F(a_{12}, a_{22}, \dots, a_{n2})$$

$$\dots\dots\dots\dots\dots\dots\dots$$

$$1 = F(a_{1m}, a_{2m}, \dots, a_{nm})$$

$$X_2 = \min\left(\frac{L_{12}}{a_{12}}, \frac{L_{22}}{a_{22}}, \ldots, \frac{L_{n2}}{a_{n2}}\right)$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$X_n = \min\left(\frac{L_{1m}}{a_{1m}}, \frac{L_{2m}}{a_{2m}}, \ldots \frac{L_{nm}}{a_{nm}}\right)$$

The model presented above will be further referred to as Linear Model A or Model LA.

If the outputs X_i in Model LA are considered as exogenous, an assumption made throughout the OECD-study except in Chapters XIV and XIX, Model LA is reduced to

$$l^d = Ax \qquad \text{(LB. 1)}$$

$$l^s = F(p, w) \qquad \text{(LB. 2)}$$

$$l^d = l^s \qquad \text{(LB. 3)}$$

$$w' A = p' \qquad \text{(LB. 4)}$$

which will be referred to as Linear Model B or Model LB.

We will now introduce the educational factors. Just as skills are inputs in the production of commodities, so is education an input in the production of skills. We remain in the Leontief universe and assume the relations between educational inputs and outputs of skills to be linear.

Consider the system of equations

$$e^d = Bl \qquad \text{(LC. 1)}$$

$$e^s = F(w, v) \qquad \text{(LC. 2)}$$

$$e^d = e^s \qquad \text{(LC. 3)}$$

$$v' B = w' \qquad \text{(LC. 4)}$$

forming a Model LC, completely analogue to Model LB.

The technological matrix B consists of the functions

$$l = F(b_{11}, b_{21}, \ldots, b_{q1})$$

$$l = F(b_{12}, b_{22}, \ldots, b_{q2})$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$l = F(b_{1n}, b_{2n}, \ldots, b_{qn})$$

The vector e' represents the educational inputs

$$\left\{ E_1, E_2, \ldots, E_q \right\} = E_k$$

These educational inputs can be considered as "years of education or training of a certain type and level". For example, E_1 may be the number of years of primary education, E_2 the number of years of secondary education, E_3 the number of years of post-secondary education, ..., E_q being the number of years of on-the-job training. In this case, the prices V_1, V_2, ..., V_q of vector v' refer to the costs of education received, V_1 being the yearly recurrent cost of investments in primary education, V_2 the yearly recurrent costs of secondary education received, etc. The equations (LC. 4)

$$V_1 b_{11} + V_2 b_{22} + \ldots + V_q b_{q1} = W_1$$

$$V_1 b_{12} + V_2 b_{22} + \ldots + V_q b_{q2} = W_2$$

$$V_1 b_{1n} + V_2 b_{2n} + \ldots + V_q b_{qn} = W_n$$

tell us that for any job category gross earnings equal investments made so that the rate of return is zero.

The elements E_1, E_2, ... E_q can, however, also be considered as the number of persons within a given educational category, in which case they correspond to the notation L_k in the OECD-study. In that case the prices V_1, V_2, ..., V_q correspond to the average wages in the educational categories concerned.

The Model LC can be treated as an independent partial equilibrium model with e^d, e^s, p and w as unknowns. It can also be joined to the Model LC so as to give the following Model LB-LC

$$l^d = Ax \qquad \text{(LB-LC. 1)}$$

$$l^s = F(p, w) \qquad \text{(LB-LC. 2)}$$

$$w' A = p' \qquad \text{(LB-LC. 3)}$$

$$e^d = B\, l^s \qquad \text{(LB-LC. 4)}$$

$$e^s = F(w, v) \qquad \text{(LB-LC. 5)}$$

$$e^d = e^s \qquad \text{(LB-LC. 6)}$$

$$v' B = w' \qquad \text{(LB-LC. 7)}$$

The system has 3m + 3q + n equations and unknowns, the unknowns being l^d, l^s, e^d, e^s, p, w and v.

In the LB-LC Model there are two distinct technological matrices, A and B. In other words, there are two implicit sets of production functions, the first being $X_i = F^1\ (L)$ and the second $L_j = F^2 \{ E \}$. If we are not interested in the occupational structure as such, X_i, can be expressed directly as a function of E_k by writing $X_i = F^1\ (F^{2^1} \{E\}\ )$. Similarly, the Model LB-LC can be reduced to

$$e^d = Gx \qquad \text{(LD-1)}$$

$$e^s = F(v, p) \qquad \text{(LD-2)}$$

$$e^d = e^s \qquad \text{(LD-3)}$$

$$v' G = p' \qquad \text{(LD-4)}$$

Model LD above is identical in structure to Model LC: we only replaced the occupational inputs by the educational inputs and matrix A by the matrix G = BA.

Each of the foregoing linear models has a neo-classical counterpart with variable input-coefficients. The counterpart of Model LB, which will be referred to as Neo-classical Model NB of Model NB, consists of

$$\begin{aligned} 1 &= F\ (a_{11}, a_{21}, \ldots, a_{n1}) \\ 1 &= F\ (a_{12}, a_{22}, \ldots, a_{n2}) \qquad \text{(NB. 1)} \\ 1 &= F\ (a_{1m}, a_{2m}, \ldots, a_{nm}) \end{aligned}$$

$$\frac{\delta X_i}{\delta L_j} \cdot W_j = P_i \qquad \text{(NB. 2)}$$

$$l^d = Ax \qquad \text{(NB. 3)}$$

$$l^s = (p, w) \qquad \text{(NB. 4)}$$

$$l^d = l^s \qquad \text{(NB. 5)}$$

The neo-classical counterpart of the LC Model will be called NC Model and is composed of

$$\begin{array}{l}1 = F(b_{11}, b_{21}, \ldots, b_{q1}) \\ 1 = F(b_{12}, b_{22}, \ldots, b_{q2}) \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ 1 = F(b_{1n}, b_{2n}, \ldots, b_{qn})\end{array} \qquad \text{(NC. 1)}$$

$$\frac{\delta L_j}{\delta E_k} \cdot V_k = W_j \qquad \text{(NC. 2)}$$

$$e^d = Bl \qquad \text{(NC. 3)}$$

$$e^s = (p, w) \qquad \text{(NC. 4)}$$

$$e^d = e^s \qquad \text{(NC. 5)}$$

The neo-classical counterparts of the Models LB-LC and LD can be derived in a similar way. It is worth while noticing that one can also amalgamate the linear Model LB with the neo-classical Model BC so as to have a Model LB-NC in which the a_{ji}'s are fixed and the b_{kj}'s are variable.

We will now present the log-linear models. They differ from the foregoing linear and neo-classical models, mainly in the following: first, the technical coefficients are removed from the demand equations and replaced by constant elasticity coefficients: second, technical coefficients and prices vary but have no effect on the elasticity coefficients concerned. In discussing these log-linear general equilibrium models, it will appear that the elasticities of the demand equations are related to the regression coefficients of specific equations in the OECD-study.

The first model of the log-linear models will be denoted as Ba and is a mixture of LB and NB. It consists of the following sets of equations:

$$\log l^d = C \log x \qquad \text{(Ba. 1)}$$

$$l^s = F(p, w) \qquad \text{(Ba. 2)}$$

$$W_j\, a_{ji} = P_i / c_{ji} \qquad \text{(Ba. 3)}$$

$$l^s = l^d \qquad \text{(Ba. 4)}$$

$$p' = w' A \qquad \text{(Ba. 5)}$$

whereby the elements c_{ji} of matrix C are constant, but the input coefficients a_{ji} are variable.

Just as in the foregoing models, the matrix C of the demand equations (Ba. 1) forms a set of production functions. They can be written* as

$$1 = F(c_{11}, c_{21}, \ldots, c_{n1})$$

$$1 = F(c_{12}, c_{22}, \ldots, c_{n2})$$

$$\ldots\ldots\ldots\ldots\ldots\ldots$$

$$1 = F(c_{1m}, c_{2m}, \ldots, c_{nm})$$

or

$$\log X_1 = \min\left(\frac{\log L_{11}}{c_{11}}, \frac{\log L_{21}}{c_{21}}, \ldots, \frac{\log L_{n1}}{c_{n1}}\right)$$

$$\log X_2 = \min\left(\frac{\log L_{12}}{c_{12}}, \frac{\log L_{22}}{c_{22}}, \ldots, \frac{\log L_{n2}}{c_{n2}}\right)$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$\log X_m = \min\left(\frac{\log L_{1m}}{c_{1m}}, \frac{\log L_{2m}}{c_{2m}}, \ldots, \frac{\log L_{nm}}{c_{nm}}\right)$$

Equations (Ba. 3) state that** for any input coefficient a_{ji}, the product of a_{ji} with the corresponding price ratio W_j/P_i is constant and

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* The production functions

$$\log X_1 = F(\log L_{11}, \log_{21}, \ldots, \log L_{n1})$$

$$\log X_2 = F(\log L_{12}, \log L_{22}, \ldots, \log L_{n2})$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$\log X_m = F(\log L_{1m}, \log L_{2m}, \ldots, \log L_{nm})$$

can be reduced to

$$1 = F(c_{11}, c_{21}, \ldots, c_{n1})$$

$$1 = F(c_{12}, c_{22}, \ldots, c_{n2})$$

$$\ldots\ldots\ldots\ldots\ldots\ldots$$

$$1 = F(c_{1m}, c_{2m}, \ldots, c_{nm})$$

by dividing the first equation through X_1, the second through X_2, ..., and putting $\log L_{ji}/\log X_i$ equal to c_{ji}.

** The equations (Ba. 3) only hold under the hypothesis that wages equal marginal productivity. In fact, those equations could also have been replaced by

$$\frac{\delta X_i}{\delta L_j} \cdot W_j = P_i/c_{ji}$$

equal to $1/c_{ji}$, implying that any increase in the relative price of input L_{ji} is compensated by a proportional decrease in the input coefficient $L_{ji}/X_i = a_{ji}$. Equations (Ba. 3) also imply that the technological matrix A can be derived from the matrix C, provided p and w are known.

The coefficients b^3_{ji} of the matrix b^3_{ji} of equations (1. 2) in the Synoptic Table are closely related to the elements c_{ji} in Model Ba. Fully written out the equations (1. 2) are $\log L_{ji}/L_i = \log a + b^3_{ji} \log X_i/L_i$.

The constant terms log a can be removed by differentiation.

The equations then become

$$\frac{d(L_{ji}/L_i)}{L_{ji}/L_i} = b^3_{ji} \frac{d(X_i/L_i)}{X_i/L_i}$$

implying that

$$b^3_{ji} = \frac{d(L_{ji}/L_i)}{d(X_i/L_i)} \cdot \frac{X_i/L_i}{L_{ji}/L_i}$$

On the other hand

$$c_{ji} = \frac{\log L_{ji}}{\log X_i} = \frac{dL_{ji}}{dX_i} \frac{X_i}{L_{ji}}$$

The difference* between b^3_{ji} and c_{ji} is, therefore, in the deflator L_i appearing in the numerator and denominator of the elasticity coefficient b^3_{ji}.

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* The relationship between c_{ji} and b^3_{ji} can be expressed as

$$c_{ji} = b^3_{ji} - (1-b^3_{ji}) \frac{dL_i}{dX_i} \frac{X_i}{L_i}$$

This relation is obtained in the following way. By definition

$$\frac{dL_{ji}}{L_{ji}} - \frac{dL_i}{L_i} = b^3_{ji} \left(\frac{dX_i}{X_i} - \frac{dL_i}{L_i}\right)$$

Shifting dL_i/L_i to the right hand side and multiplying both sides by X_i/dX_i gives

$$\frac{dL_{ji}}{L_{ji}} \frac{X_i}{dX_i} = b^3_{ji} \cdot - (1-b^3_{ji}) \frac{dL_i}{dX_i} \frac{X_i}{L_i} = c_{ji}$$

If the vector $x' = X_i$ in (Ba. 1) is reduced to a scalar X, standing for production of the whole economy then Model Ba becomes

$$\left[\log L_j^d \right] = \left[c_j \right] \log X \qquad \text{(Bb. 1)}$$

$$L_j^s = F(P, W_j) \qquad \text{(Bb. 2)}$$

$$W_j \, a_j = P/c_j \qquad \text{(Bb. 3)}$$

$$L_j^s = L_j^d \qquad \text{(Bb. 4)}$$

$$\frac{W_1}{P} a_1 + \frac{W_2}{P} a_2 + \ldots, \frac{W_n}{P} a_n = 1 \qquad \text{(Bb. 5)}$$

where $\left[\log L_j^d\right]$ and $\left[c_j\right]$ are diagonal matrices and log X is a scalar.

In the line with the foregoing model, the input coefficients L_1/X, $L_2/X, \ldots, L_n/X$ are variable but $\frac{L_1}{X} \; \frac{W_1}{P}, \frac{L_2}{X} \; \frac{W_2}{P}, \ldots, \frac{L_n}{X} \; \frac{W_n}{P}$ the shares of the various occupational groups in national income, are constant and the elasticity of substitution between any two inputs is equal to 1.

The counterpart of equation (Bb. 1) in the OECD-study is equation (1. 1a) of Synoptic Table. The coefficients b_j^1 of equation (1. 1a) equal $\frac{d(L_j/L)}{d(X/L)} \; \frac{X/L}{L_j/L}$, while the coefficients c_j of (Bb. 1) equal $\frac{dL_j}{dX} \; \frac{X}{L_j}$, the difference being in the deflator L. *

If the skill production models are put in log-linear form, the following Model C is obtained.

$$\log e^d = D \log 1 \qquad \text{(C. 1)}$$

$$e^s = F(w, v) \qquad \text{(C. 2)}$$

$$V_k \; b_{kj} = W_j/d_{kj} \qquad \text{(C. 3)}$$

* The relationship between c_j and b_j^1 can be expressed as

$$c_j = b_j^1 - (1 - b_j^1) \frac{dL}{dX} \quad \frac{X}{L}$$

It may be observed that in Model Bb concerned X and L are exogenous.

$$e^d = e^s \qquad (C.4)$$

$$w' = v' B \qquad (C.5)$$

where $d_{kj} = \log L_{kj} / \log L_j$.

The counterparts of the coefficients d_{kj} in the OECD-study are the coefficients b^8_{kj} and b^9_{kj}.

The models Ba and C can be amalgamated and contracted so as to give

$$\log e^d = H \log x \qquad (Ba\text{-}C.1)$$

$$e^s = f(p, v) \qquad (Ba\text{-}C.2)$$

$$V_k \; g_{ki} = W_j P_j / h_{ki} \qquad (Ba\text{-}C.3)$$

$$e^s = e^d \qquad (Ba\text{-}C.4)$$

$$p' = v' G \qquad (Ba\text{-}C.5)$$

where G = BA and H = DC while the models Bb and C can be put together and reduced to

$$\left[\log D^d_k\right] = \left[\log L^d_k\right] = \left[h_k\right] \; \log X \qquad (Bb\text{-}C.1)$$

$$E^s = L^s_k = F(P, V_k) \qquad (Bb\text{-}C.2)$$

$$V_k \; g_k = P / h_k \qquad (Bb\text{-}C.4)$$

$$\frac{V_1}{P} \, g_1 + \frac{V_2}{P} \, g_2 + \ldots, + \frac{V_9}{P} \, g_9 = 1 \qquad (Bb\text{-}C.5)$$

where $\left[\log E_k\right]$, $\left[\log L_k\right]$ and $\left[h_k\right]$ are diagonal matrices and $\log X$ is a scalar.

The counterparts of the coefficients h_k in the OECD-study are the coefficients b^4_k of equation (2.1a) in Synoptic Table.

The Model C can be reversed so as to give

$$\log l^d = T \log e \qquad (D.1)$$

$$l^s = F(w, v) \qquad (D.2)$$

$$W_j s_{jk} = V_k / t_{jk} \qquad (D.3)$$

$$l^s = l^d \qquad (D.4)$$

$$v' = w' S \qquad (D.5)$$

That Model D is the reciprocal of Model C can be best shown, when it is assumed that D and B are square and non-singular: in that case I is simply D^{-1} and $S = B^{-1}$.

The counterparts of the coefficients $t_{jk} = \log L_{jk} / \log E_k$ in the OECD-study are the coefficients b^{10}_{jk} and b^{11}_{jk} of equations (3.2a) and (3.2b) of Synoptic Table.

If the Models D and Ba-C are joined together and reduced, the Model Ba is again obtained.

Let us now discard the problem of price equilibrium, forget about the input coefficients and eliminate the supply equations.

We are left then with two truncated models.

The first consists of

$$\log l^d = C \log x \qquad (1.1a)$$

$$l^d = l^s \qquad (1.2)$$

$$\log e^d = D \log l^s \qquad (1.3)$$

where (1.1a) is (Ba.1), (1.2) is (Ba.4) and (1.3) is (C.1).

The second model is composed of

$$\log e^d = H \log x \qquad (2.1a)$$

$$e^d = e^s \qquad (2.2)$$

$$\log l^d = T \log e^s \qquad (2.3)$$

where (2.1a) is (Ba-C.1), (2.2) is (Ba-C.4) and (2.3) is (D.1).

Models 1a and 2a above are distinct but related. The equations (2.3) are the inverse relationship of (1.3): when matrix D is square and non-singular, then T is simply D^{-1}. Equations (1.1a) are reduced forms of (2.1a), (2.2) and (2.3): $\log l^d = TH \log x = D^{-1} Hx = Cx$. Similarly, equations (2.1a) are reduced forms of (1.1a), (1.2) and (1.3): $\log e^d = DC \log x = H \log x$. Since (2.1a) are reduced forms of (1.1a), (1.2) and (1.3), and (2.3) are the inverse relationships of (1.3), all the information contained in Model 2a is already embodied in Model 1a.

If the vector x in (1. 1a) and (1. 1b) is reduced to a scalar X, then Model 1a becomes

$$\left[\log L_j^d\right] = \left[c_j\right] \log X \qquad (1.1b)$$

$$l^d = l^s \qquad (1.2)$$

$$\log e^d = D \log l \qquad (1.3)$$

and Model 2a becomes

$$\left[\log E_k^d\right] = \left[h_k\right] \log X \qquad (2.1b)$$

$$e^d = e^s \qquad (2.2)$$

$$\log l^d = T \log e^s \qquad (2.3)$$

where $\left[\log L_j\right]$, $\left[\log E_k\right]$, $\left[c_j\right]$ and $\left[h_k\right]$ are diagonal matrices and log X is a scalar. The models above will be denoted as Model 1b and Model 2b, respectively.

It has already been shown that the regression coefficients of a number of equations in Synoptic Table are related to the elasticities of the demand equations in the general log-linear models. We will now more systematically review the regression coefficients of Synoptic Table and indicate to which parameters of the truncated log-linear models they correspond.

Equations (1. 1a) and (1. 1b) of Synoptic Table estimate the parameters c_j, equations (1. 2) the parameters of the matrix C, equations (2. 1a) the parameters h_k, equations (3. 1a) and (3. 1b) the parameters of the matrix D, and (3. 2a) and (3. 2b) the parameters of matrix T. The equations (3. 2a bis) are similar to (3. 2a) but instead of having L as deflator in the numerator and denominator of the elasticity coefficient $\frac{\log L_{kj}/L}{\log L_j/L}$, the numerator has L_j as deflator and the denominator has L. Equations (2. 2) of Synoptic Table estimate the parameters of the equation

$$\left[\log E_k\right] = \left[d_j\right] \quad \left[\log L_j\right]$$

where $\left[\log E_k\right]$, $\left[d_j\right]$ and $\left[\log L_j\right]$ are diagonal matrices and the diagonal matrix $\left[d_j\right]$ is a condensed form of matrix D.

A number of equations of the Synoptic Table, more particularly the sets (4) and (4bis) and the production function (5), cannot be connected to one of the two models above.

The set (4) can only be integrated into a simple model such as

$$\left[\log L_{jk}\right] = U \log X \tag{4.1}$$

$$L_j = \sum_{k=1}^{q} L_{jk} \tag{4.2}$$

$$L_k = \sum_{j=1}^{n} L_{jk} \tag{4.3}$$

where $\left[\log L_{jk}\right]$ and U are matrices and log X is a scalar.

I do not consider models such as Model 4 above to be very attractive, inter alia, because they have no structural equations relating L_k to L_j and there is little scope for completing them with additional equations. The coefficients $b^{16}_{jk} = \frac{\log L_{jk}/L_j}{\log X/L}$ of equations (4bis) are similar to the corresponding coefficients of equations (4): the only difference is in the deflator of the numerator, which is L_j for equations (4bis) and L in equations (4).

The production function (5)

$$\log X = \text{a constant} + b_1 \log Lk_A + b_2 \log (L - Lk_A) + b_3 \log K$$

is the familar Cobb-Douglas function, which has two same characteristics as the log-linear models presented above: the categorical incomes are constant and the elasticities of substitution equal to 1.

2. SIGNIFICANCE OF THE ESTIMATED PARAMETERS

It has been shown in the foregoing section that the major sets of elasticity coefficients estimated in the OECD-study correspond to the parameters of specific sets of structural equations in specific log-linear models.

Estimating and testing those elasticity coefficients is equivalent to estimating and testing the parameters of the corresponding equations.

The more significant the parameters, the more significant the underlying equations and the models, to which those equations belong.

In the following paragraphs will be briefly examined which elasticity coefficients come out as statistically best and what this implies with respect to the validity of the different models presented in the foregoing section.

Fitting production functions such as

$$\log X = \text{a constant} + b_1 \log Lk_A + b_2 \log (L - Lk_A) + b_3 \log K \tag{5}$$

fails because the independent variables are collinear. Sometimes, however, it is possible to get around the problem of collinearity, which, incidentally, also arises when fitting the usual Cobb-Douglas function and the CES-production function. In this respect it is worth while noticing that since, $L - Lk_A \simeq L$, function (5) can also be written as

$$\log X/L = \text{a constant} + b_1 \log (Lk_A/L) + b_2 \log (K/L) \qquad (6)$$

Putting the variables in deflated form, as has been done by the authors in all other equations, and making a regression with the deflated variables may diminish the influence of the "scale effects", which seem to have caused part of the collinearity.

The elasticity coefficients b^{12}_{jk} estimated by equations (4) of Synoptic Table are significant but in many cases the correlation coefficients are quite low.

Model 4 consisting of

$$\left[\log L_{jk} \right] = U \log X \qquad (4.1)$$

$$L_j = \sum_{k=1}^{q} L_{jk} \qquad (4.2)$$

$$Lk = \sum_{j=1}^{n} L_{jk} \qquad (4.3)$$

can be applied but the errors involved in the summations (4.2) and (4.3) will be quite high. Even so, equation (4.1) can be usefully applied to determine the numbers to be trained in specific educational categories of specific occupational groups, more in particular those for which the corresponding coefficient u_{jk} is most significant*.

The coefficients b^1_j of equations (1.1a) and the coefficients b^8_{kj} of equations (3.1a) are significant and the correlations are in most cases impressively high. It follows that we obtain good parameters for the structural equations of Model 1b:

$$\left[\log L^d_j \right] = \left[c_j \right] \log X \qquad (1.1b)$$

$$1^s = 1^d \qquad (1.2)$$

$$\log e^d = D \log 1^s \qquad (1.3)$$

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* The same holds for the parameters of equations similar to (4.1) such as:

$$\log L_{jk}/L = b_{jk} \log X/L + b_{jk} \log L_k/L$$

$$\log L_{jk}/L = b_{jk} \log L_k/L + b_{jk} L_j/L$$

The former of the equations above appears in Table III-8 and the latter in Table III-9 of the OECD-study.

Similarly, the coefficients b_k^4 of equations (2.1a) of Synoptic Table and b_{jk}^{10} of equations (3.2a) are highly significant. It follows that we also obtain good parameters for Model 2b:

$$\left[\log E_k^d\right] = \left[h_k\right] \quad \log X \qquad (2.1b)$$

$$e^d = e^s \qquad (2.2)$$

$$\log l^d = T \log e^s \qquad (2.3)$$

Statistically both models come out equally well: the estimated parameters of T come out somewhat better than the parameters of D, but on the other hand the estimated parameters c_j are somewhat better than the estimated parameters h_k.

From the theoretical standpoint, however, Model 1b is more appealing than Model 2b because equations (1.3) have more sense than equations (2.3). Equations (1.3) say that there is a set of activity vectors $d_{k1}, d_{k2}, \ldots, d_{kn}$ transforming educational inputs into skills, which is perfectly meaningful. One cannot attach the same meaning to the transformation matrix T, because one would have to say that there exists a set of activity vectors $t_{j1}, t_{j2}, \ldots, t_{jq}$ transforming skills into graduates.

The coefficients b_{kj}^9 and b_{jk}^{11} are also significant although the correlation coefficients are generally somewhat lower than for b_{kj}^8 and b_{jk}^{10} It may be recalled that b_{kj}^9 is identical to b_{kj}^8 but for the deflator, which is X instead of L. The same holds for b_{jk}^{11} and b_{jk}^{10}. That the coefficients $b_{jk}^{15} = \dfrac{\log L_{jk}/Lj}{\log L_k/L}$ are insignificant may be ascribed to the fact that the deflator is L_j in the numerator and L in the denominator. The same holds for the coefficients b_{jk}^{16}.

Finally, it should be noted that the coefficients b_{ji}^3 corresponding to the parameters c_{ji} of matrix C of equation

$$\log l^d = C \log x \qquad (1.1a)$$

have a high significance level only for the column pertaining to the manufacturing sector.

3. LIMITATIONS OF THE STUDY AND AREAS FOR FURTHER RESEARCH

A model such as

$$\left[\log L^d\right] = \left[c_j\right] \quad \log X \qquad (1.1b)$$

$$l^d = l^s \tag{1.2}$$

$$\log e^d = D \log l^s \tag{1.3}$$

albeit deprived of supply equations, is attractive in several ways. It is interesting from a theoretical standpoint, because we have a function (1.1b) telling us how educational inputs are transformed into skills. It is practical as an instrument of forecasting because both occupational and educational categories can be derived straightforwardly on the basis of target rate of growth of GDP. The limitation of the model as an instrument of forecast and policy-making can be expressed as follows: the forecasts tell how many persons will work in the various skill categories and educational categories, but we do not know if those persons will be really required. This limitation results of the fact that the parameters c_j and d_{kj}, as estimated by the OECD-study, only translate the average behaviour of a number of countries and merely reflect ex-post equilibria of supply and demand. The model explains how those countries have been able to fulfil the demand for various jobs and graduates, given the available supply and the structure of the educational system. It has a solution, which may be optimal, but most probably is not optimal. The limitations in the formal structure of the model result mainly from the assumed constancy of the elasticity coefficients c_j and d_{kj}, which remain unchanged whatever the prices V_k and W_j.

There is a way to let the prices have their effect on c_j and d_{kj}: by introducing elasticities of substitution and letting c_j and d_{kj} be variables.

Consider the simple model

$$\begin{aligned} \log E_1^d &= d_1 \log L_1 \\ \log E_2^d &= d_2 \log L_1 \end{aligned} \tag{6.1}$$

$$\begin{aligned} E_1^d &= E_1^s \\ E_2^d &= E_2^s \end{aligned} \tag{6.2}$$

$$\log E_1^s - \log E_2^s = -\rho \, (\log V_1 - \log V_2) \tag{6.3}$$

$$\frac{1}{d_1} + \frac{1}{d_2} = 1 \tag{6.4}$$

which has two educational inputs, E_1 and E_2 and one occupational category, L_1.

The term ρ stands for the elasticity of substitution between E_1 and E_2 and equation (6.3) is derived from the definition of the elasticity of substitution.

$$\rho = - \frac{\log (E_1/E_2)}{\log r}$$

Replacing r, the marginal rate of substitution, by the price ratio V_1/V_2 gives equation (6.3) and at the same time meets the optimality condition that marginal costs have to equal marginal revenue. In the model above, W_1, V_1 and V_2 are exogenous, while E_1^s, E_1^d, E_2^s, E_2^d, d_1 and d_2 are variables*. The solution of this model is optimal for the reason mentioned earlier: we have the hidden side-relation $r = V_1/V_2$, "marginal costs equal marginal revenue", which is the criterion function or objective function of all neo-classical models. The model could be easily extended so as to include more educational inputs.

We could also re-enter the function $\log L_j = c_j \log X$ and make the c'_{js} variable on the condition that we introduce at the same time elasticities of substitution of the form

$$\frac{\log (L_1/L_2)}{\log (W_1/W_2)}, \frac{\log (L_2/L_3)}{\log (W_2/W_3)}, \text{ etc.}$$

What additional information does a model like 6 require compared with Models like 1 and 2? In the first place the knowledge about the prices W_j and V_k. It has been said in section 1 that V_k can mean either the yearly recurrent cost of investments in a given level and type of education E_k, or as the wage level of educational group E_k.

Some data already exist on comparative incomes of persons with "more" or "less" education. Little information is, however, available on the earnings associated with skill levels and occupational categories. Very few data exist on costs of alternative ways of training, especially on the least expensive ways of training, such as part-time training and on-the-job training. It is almost trivial to say that a comprehensive knowledge on costs and earnings are a prerequisite for the making of more complete and relevant educational planning models.

Next, there are the elasticities of substitution. What information is required to estimate an elasticity of substitution as, for example, ρ? Let L_1 of our illustrative model (6) refer to the skill group of mechanics, let E_1 be the number of years of vocational training required to become mechanic and E_2 the corresponding number of years of on-the-job training. Then b_1 and b_2 are the variable input coefficients E_1/L_1 and E_2/L_1. If the isoquant on Diagram 1 refers to the iso-skill curve

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* In condensed form the above model is

$$\log E_1 = d_1 \log L_1$$

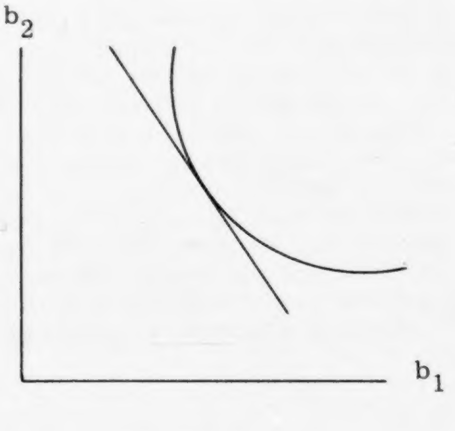
$$\log E_2 = d_2 \log L_1$$

$$d_1 - d_2 = -\rho \frac{\log (V_1/V_2)}{\log L_1}$$

$$\frac{1}{d_1} + \frac{1}{d_2} = 1$$

for mechanics, then $-r = \frac{db_1}{db_2}$ is the marginal rate of substitution of b_1 for b_2 and $-\rho = \frac{\log b_1/b_2}{\log r}$ is the elasticity of substitution, reflecting the curvature of the isoquant. Exceptionally, one may be able to know the elasticity of substitution without knowing anything about the shape of the curve*. Normally, however, one has to know the shape of the iso-product or iso-skill curve in order to know the elasticity of substitution. The foregoing implies that the knowledge of which is required to transform Models 1 and 2 into an optimizing model with variables elasticities such as Model 6, is the same knowledge we need to apply the linear and neo-classical model.

Diagram 1. ELASTICITY OF SUBSTITUTION ALONG A ISO-SKILL CURVE



Indeed, determining the shape of the isoquant corresponds to finding a set of input combinations:

$$\begin{bmatrix} b_1^1 \\ \\ b_2^1 \end{bmatrix} \quad \begin{bmatrix} b_1^2 \\ \\ b_2^2 \end{bmatrix} \quad \begin{bmatrix} b_1^3 \\ \\ b_2^3 \end{bmatrix}$$

all giving the required skill for occupation j. Once these alternative input combinations are known, one can apply either an improved version of linear Model LC or the neo-classical Model NC or the log-linear Model 6.

The improved version of the linear model would be a linear programming model. Saying that there are alternative ways of skill acquisition corresponds to saying that are alternative vectors for every column vector j of the transformation matrix B in Model LC.

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* The estimation of the elasticity of substitution between capital, K, and labour, L, by means of the equation:

$\log (\frac{K}{L}) =$ a constant + $\log W$ is one of the exceptional cases referred to.

Given these alternative combinations and given the prices V and W, one can choose among the alternatives the set of column vectors b_{kj}, which minimizes the criterion function $w' = v' B$ and use the matrix B obtained for determining the optimal inputs E_k by equation $e = BI$.

Following, this strategy relaxes the assumption of constant input-output relations and makes the linear model flexible*. In a two-factor model such as 6 the procedure outlined above would correspond to finding the optimal inflection point along a kinked isoquant.

The neo-classical approach would proceed in a very similar way: given the shape of the isoquant, the marginal rate of substitution can be determined**, and the optimal input coefficients b_1 and b_2 are those for which $-db_1/db_2$ equals the price ratio V_2/V_1.

However, as little information is available on costs of alternative ways of training, as fragmentary is our knowledge on alternative ways of skill acquisition. Up to now most of the attention was concentrated on institutional training. Although formal training is the major input in the process of skill acquisition, there is a realm of other important factors, such as experience, intelligence, health, sex, language, culture, etc., which determine skill formation. Not much is known about the importance of the latter factors nor about the network of interrelationship among those factors and between those factors and formal education itself. Data collection and piecemeal engineering in those unexplored fields are, it seems to me, essential in order to make further progress in the broader area of educational planning.

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* In an interesting study O. Mehmet has used a model of this type to determine the optimal allocation of government funds between institutional and on-the-job training. O. Mehmet: Optimum Choice Between Institutional and On-the-Job Adult Manpower Training Activities in the Province of Ontario, mimeographed doctoral thesis, University of Toronto, 1968.

** Author of this paper has constructed empirical isoquants of the type presented in Diagram 1 for a limited number of skill groups and derived the marginal rates of substitution between formal training and on-the-job experience, in: "Formal Training and On-the-Job Experience as Substitutes", ILR, September, 1969.

SYNOPTIC TABLE SUMMARIZING THE MAJOR SETS OF REGRESSION EQUATIONS PRESENTED IN THE OECD-STUDY

	NATURE OF THE RELATIONSHIP	CORRESPONDING REGRESSION EQUATION OR SET OF REGRESSION EQUATIONS	NUMBER OF THE EQUATION OR SET OF EQUATIONS	EXPLANATORY REMARKS ON THE NATURE OF THE VARIABLES	TABLE AND CHAPTER OF REFERENCE IN THE OECD-STUDY
(1, 1)	$L_j^d = F(X)$ where L_j^d is the demand for L in skill group j	$[L_j/L] = [b_j^1]\ X/L$ $[L_j/X] = [b_j^2]\ X/L$	1, 1a 1, 1b	$[L_j/L]$, $[L_j/X]$ and $[b_j]$ are diagonal matrices, X/L is a scalar	Table II-1, Chapter VI Chapter VIII and XIII
(1, 2)	$L_{ji} = F(X)$ where i refers to economic sector i	$[L/_{ji}/L_i] = [b_{ji}^3]\ [X_i/L_i]$	1, 2	$[L_{ji}/L_i]$ and $[b_{ji}^3]$ are matrices, $[X_i/L_i]$ is a diagonal matrix	$[L_{j1}/L_1] = [b_{j1}^3]\ X_1/L_1$ is in Table II-2 $[L_{j2}/L_2] = [b_{j2}^3]\ X_2/L_2$ is in Table II-3, etc.
(2, 1)	$L_k^d = F(X)$ where L_k^d is demand for L of educational level k	$[L_k/L] = [b_k^4]\ X/L$ $[k_j] = [b_j^5]\ X/L$ $[L_k/X] = [b_k^6]\ X/L$	2, 1a 2, 1b 2, 1c	X/L is a scalar, all terms between [ ] are diagonal matrices	Table III-1 and III-2, Chapter X Table III-3, Chapter X Graphs III-17 and III-18, Chapter XIII
(2, 2)	$L_k = F(L_j)$	$L_k/L = b_{kj}^7\ L_j/L$ $k = 1, 2, \ldots, 9$ $j = 1, 2, \ldots, n$	2, 2		Table III-10, Chapter XII
(3, 1)	$L_{jk} = F(L_j)$	$[L_{kj}/L] = [b_{kj}^8]\ [L_j/L]$ $[L_{kj}/X] = [b_{kj}^9]\ [L_j/X]$	3, 1a 3, 1b	$[L_{kj}/L]$, $[L_{kj}/X]$ and $[b_{kj}]$ are matrices, $[L_j/L]$ and $[L_j/X]$ are diagonal matrices	Table III-6, Chapter X Table III-11, Chapter XIII
(3, 2)	$L_{jk} = F(L_k)$	$[L_{jk}/L] = [b_{jk}^{10}]\ [L_k/L]$ $[L_{jk}/X] = [b_{jk}^{11}]\ [L_k/X]$	3, 2a 3, 2b	Idem as in 3, 1a/3, 1b	Table III-8, Chapter XI Table III-12, Chapter XIII
(4)	$L_{jk} = F(X)$	$[L_{jk}/L] = [b_{jk}^{12}]\ X/L$	4	$[L_{jk}/L]$ and $[b_{jk}]$ are matrices and X/L is a scalar	Table III-2, Chapter X
(5)	$X = F(Lk_A, L, K)$ where K stands for accumulated investments and Lk_A for university graduates	$X = b_1^{13}\ Lk_A + b_2^{13}\ (L - Lk_A) + b_3^{13}\ K$	5		Chapter XIV
(3, 2 bis)	$L_{jk} = F(L_k)$	$[L_{jk}/L_j] = [b_{jk}^{15}]\ L_k/L$	3, 2a bis	$[L_{jk}/L_j]$ and $[b_{jk}]$ are matrices, $[L_k/L]$ is a diagonal matrix	Table III-8, Chapter XI
(4 bis)	$L_{jk} = F(X)$	$[L_{jk}/L_j] = [b_{jk}^{16}]\ X/L$	4 bis	$[L_{jk}/L_j]$ and $[b_{jk}]$ are matrices and X/L is a scalar	Table III-1, Chapter X

4

SKILLED MANPOWER AND GROWTH

by

Josef Steindl

1. The material used by this Report is the educational and occupational structure as well as the national product per head of a cross section of countries in approximately the same year. Economists starved of data are happy to have such a cross section at least, and we are grateful to the valiant efforts of the authors of this Report* who have analysed the data with great discrimination and assiduity. The chances of obtaining results from this information are severely limited by the fact that it is a cross section and no more. The character of the material has dictated the form of the question asked which is roughly: what are the relations between educational (or occupational) structure and the degree of complexity or advancedness of an economy, as measured by national product per worker ? And this question, put to the cross-section material, implies a theory that the manpower requirements in a certain year depend on the advance, complexity, and hence productivity which is realized simultaneously in that country.

I do not think this is a reasonable theory. Nor will a cross-section relation between skill densities and productivity in one year ever allow us to differentiate effectively between supply and demand relations. There are, to be sure, two kinds of relations between the density of, say, graduates in a population, and the national product per head. The one relation is based on the fact that parents invest more money and time in the education of their children when they are better off; thus when incomes increase the output of graduates rises a number of years later (depending on the length of the pipeline). But the full effect on the stock of graduates works out only over the whole span of a working life. Thus the average lag between income (national product per worker) and the stock or density of graduates will be about two decades plus the length of the pipeline. This nexus may be called the supply relation.

The other nexus, the demand relation, is based on the presumed fact that an additional use of skilled people, under certain conditions, will yield an increment in national product per employee. This connection is usually put in a somewhat different form: one speaks of the requirements in skilled manpower of a certain (additional) national product.

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* Occupational and Educational Structures of the Labour Force and Levels of Economic Development, Possibilities and Limitations of an International Comparison Approach. (OECD - DAS/EID/69.16).

This second form of the demand nexus, properly interpreted, is equivalent to the first, but it suggests rather more the idea of a straightforward deterministic (as opposed to a stochastic and not easily accessible) formula, which in fact is realized in the form of standards used in manpower forecasting (so many pupils per teacher, patients per doctor, etc.), which are, however, by no means identical with the (largely unknown) actual empirical nexus between input and output. Now this empirical demand nexus involves again a time lag. The output consequent on an input in research and development will start to flow in most cases only a good many years later, and the full benefit obtained may extend over an even longer period. All planning activities similarly yield their fruits only a number of years later. Even the application of new methods (after the development stage) involves an initial investment of skilled efforts at the start of a long production run.

Thus there is a distributed lag between input of skilled manpower and its effect on output.

The two lagged relations: National product per worker - skill density a few decades later - National product per worker perhaps 10 years later - are reflected in the cross section regressions of occupational and educational structure on simultaneous National Product, owing to the auto-correlation of the time series, but they are inextricably mixed up.

The Report suggests that the occupational regressions correspond mainly to the demand nexus, and the educational regressions to the supply nexus, and M. Malinvaud has neatly formalized this approach.

But this interpretation somehow suggests that education is of no consequence: You dilute your manpower more or less, as the level of activity dictates, given the supply of graduates by the educational system. But what if the economy' s level of activity is itself strongly influenced by the educational system' s output some time ago ? That, after all, is the decisive question, as I see it, and the cross-section data give us hardly even a hint of an answer.

2. But my objection against the theory tested by the Report goes further. The theory is that skilled manpower densities are related to the level of output per worker. I think that only part of skilled manpower is related to the level of output; an appreciable part is related to the rate of change of output. In fact a part of the input of skilled manpower plays the same role as investment and is therefore subject to the acceleration principle*.

This is easy to see in the case of teachers. The stock of teachers (corresponding to a capital stock) has to expand pari passu with the demand for school places which depends on the growth of the population, or on the speed with which analphabetism is reduced, or on the rate of increase in school participation. The greater the growth of population and the growth rate of school participation, the larger the requirements of teachers. This principle can be immediately extended to industry: A fast growing firm which has a large influx of new labour at various levels needs more experienced people to train the newcomers. The great role which teaching plays in industry is increasingly appreciated; its scope is developing and it is becoming more systematic as a consequence of the quick change of technology.

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* I elaborated this point some time ago: see J. Steindl, "The Role of Manpower Forecasting in the Educational Planning Experience of the Austrian E. I. P. team" Manpower Forecasting in Educational Planning, OECD, Paris, 1965, pp. 72-74.

More generally it has to be recognized that the concept of investment applies not only to machines and other material investment, but to immaterial investment as well, such as education and training, research and development, planning and preparation of material investment.

The analogy between immaterial and material investment is obscured by the fact that the former is not capitalized in the books and its results are not as tangible as a machine. If we want an analogy to the material capital stock we should have to think of a stock of know-how which has to expand pari passu with the level of productivity of the economy.

The real reason for extending the acceleration principle to these forms of investment is not the analogy, but the observation that research and development, planning, project-making and learning to run a new equipment are all complementary to material investment. Since the material investment is related to the rate of increase in output, so is the immaterial investment linked to it, and therefore also the corresponding input of skilled manpower.

In other words: A higher rate of growth involves a quicker acquisition, diffusion and application of know-how, and this requires greater densities of highly skilled personnel.

3. The importance of the acceleration principle in educational planning might be illustrated by a model which purports nothing more than to show the analogy between material investment and education.

It is the Harrod-Domar relation, applied to the reproduction of skilled manpower.

Assume that the input of skilled manpower consists of two parts, one devoted to teaching (T), and the rest to other tasks (which might be termed "production"). The first part corresponds to investment, the second to consumption in Harrod's model.

We have the following relations to determine n, the total number of skilled people, and n' , the part of them employed in production:

$$n_t = \frac{1}{K} \quad T_{t-\theta} \qquad (1)$$

$$n_t = \Delta T_t + r\, n_t + n'_t \qquad (2)$$

$$n'_t = (1 - \alpha) \quad n_t \qquad (3)$$

which means: (1) By devoting a man to teaching you get 1/K skilled men θ years later (K: inverse pupil-teacher ratio, in Harrod's case capital-output ratio). (2) The total skilled manpower consists of the part which is employed in production, n', and the part which is devoted to teaching, of which one part, $r\, n_t$ is only reproducing the existing skilled manpower (it is an amortization quota), and another, $\Delta\ T$, is engaged in expanding it. (3) a proportion α of the total skilled manpower is devoted to teaching (this is the "gross savings ratio").

The above system of equations can be dealt with as follows.

From (2) and (3) we have:

$$n_t = \Delta T_t + r\, n_t + (1 - \alpha)\, n_t$$

$$(\alpha - r)\, n_t = \Delta\ T_t$$

$$(\alpha - r)\, T_{t-\theta} = K\ \Delta\ T_t \qquad (4)$$

We now put $T_t = x^t$ (where $x = 1 + \rho$, ρ being the yearly rate of growth). Dividing both sides of (4) by T_t and substituting we have:

$$(\alpha - r)\, x^{-\theta} = K\ (x - 1)$$

so that for the rate of growth ρ we have the equation

$$\rho = \frac{\alpha - r}{K}\ (1 + \rho)^{-\theta} \qquad (5)$$

(The growth rate of teachers is necessarily the same as that for all skilled manpower in a smooth growth process).

This is the same as the Harrod-Domar relation in so far as the growth rate is determined roughly by the ratio of the savings rate to the teacher-pupil (capital-output) ratio. This result is, however, modified by the effect of the training period θ, (which is of course an adverse effect and which is the stronger the greater the rate of growth. [The numerical growth rate must be calculated by iteration from (5)] .

We might now try to take account of the fact that the non-teaching manpower in the above model really consists of two parts: One which aids current production, and one which contributes only to future production, for example, R and D. If we assume, in analogy to the Harrod-Domar model, that the R and D similar future oriented input of skilled manpower bears a constant relation to the rate of increase in national output, we obtain a model quite similar to the above one, the difference being that "saving" now means a transfer of skilled men from current production to research and development, planning, etc.

Thus it appears that the acceleration principle really works in two stages as it were so that not only the first, but also the second derivative of national product, influence the demand for skilled manpower.

The Harrod-Domar models show that some countries are in a difficult position when they have to build up a stock of skilled manpower, and for this purpose must transfer skilled manpower from current production to teaching. The difficulties might be very drastic, if the build up is quick. Fortunately, it seems, the parameters of the problem are not quite rigid. The pupil-teacher ratio can increase, if we assume that teachers are not yet fully utilized; there is, further, the possibility of importing or borrowing skilled manpower from abroad.

The acceleration principle, here as elsewhere, is not rigidly applicable, the existence of reserves making it strictly speaking inoperative. Also the assumption of a constant capital output ratio is only a first approximation. In a weakened form the accelerator principle remains relevant, however, and the above models might have, therefore, some didactic value*. For the educational planner, clearly, they are insufficient, because he is not concerned with smooth growth, but with a transition from given initial conditions to a given target. He needs a dynamic model in which the rigid initial conditions and the time required to unfreeze them play a decisive role.

In dynamic conditions there appears, incidentally, a problem which is foreign to the steady state growth: since some immaterial investment such as education takes very long to mature, the waiting time will be relevant for the planner as well as the return. In fact there will be conflicts of interest between different generations involved.

4. From the investment character of a large part of the input of skilled manpower it may be concluded that quickly growing economies have greater manpower requirements than slow growing ones. Some of the developing countries shown in the Report as over-educated (e.g. Graph. III-4 p. 173, III-12, p. 186) might in fact need this apparently excessive manpower (e.g. as teachers and for training in industry) to facilitate their rate of growth which is bound to be large for a developing country just getting into its stride. Certainly the case of Japan would suggest that her large rate of growth might be connected with her large manpower requirements.

But this is certainly not the only explanation for the fact which has been shown in the Report that different countries on the same economic level show widely varying skill-densities. In some countries there is disguised unemployment of skilled manpower which is sometimes the result of outmoded forms of education (often strikingly evident in some developing countries which have inherited from their colonial past a class of educated people trained in humanities and ill suited for the urgent needs of these countries while technological skills and scientists are scarce). The Report in its conclusion points out the decisive role of quality in the question of manpower requirements.

Another reason for disparity is that the efficiency of skilled manpower - or rather the effectiveness of its use - may vary widely. Some countries have considerable numbers of skilled manpower in research and development without any corresponding results in productive achievement, owing to deficiencies in communication, organisation and management.

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* It need hardly be mentioned that rigid complementarity between machines and the preceding or accompanying immaterial investment cannot be presumed. Outside a certain range, however, a growing disproportion between the two will lead to rapidly declining returns. The really relevant question is where these limits are in practice.

The manpower requirements of administration differ widely and are influenced by rather irrational factors. There are obviously countries in which the number of civil servants employed is dictated by political considerations. It is hardly surprising, under the circumstances, that we find vastly different patterns of employment of skilled personnel.

Again, it is well known that under certain conditions skilled manpower can be substituted by imported know-how. There is no doubt that at the development stage these imports play a large role. They are based on the interests of the sellers of machinery who provide technical aid and training of manpower. In industrial countries, on the other hand, which compete in exporting to third markets, it seems there has to be give and take in the exchange of technical knowledge, and a mere reliance on imported know-how is not compatible with this stage of development. Since there are so many reasons for the wide disparities in manpower patterns shown by the Report it would be rash to draw any conclusions to the effect "that the importance of manpower is less than has been thought".

5. Nothing in the patterns shown by the Report contradicts the view that availability of skilled manpower of the right type (unless there are strong institutional impediments) may actively stimulate growth. I believe this all the more strongly since I have come to regard the functions of skilled manpower in a new light. Those who actually produce new knowledge are a minority, and as far as they are concerned the protagonists of a narrow intellectual elite might have a case. Owing to the ever greater complexity of our society, however, the propagation or diffusion of knowledge has acquired an enormous importance as compared with its production (this offers an analogy to the increased importance of distribution as compared with production of commodities).

In order to become effective, new technical knowledge has to be spread. This process has in the first place to reach certain strategic points: The people who are in a position of authority and who can set in motion a practical realization of projects which make use of the knowledge - managers and high officials. This transmission of decisive technical knowledge cannot be wholly organised: It remains a stochastic process to get the relevant ideas into the heads of persons who have the power to realize them.

What can be done to facilitate this is to make the net of potential carriers of the "infection" sufficiently dense to make it likely that somebody will catch the new knowledge. In other words, society has to be made conductive by the presence of a sufficient number of interpreters who are enabled by their training to transmit scientific information.

The function of these people may also be regarded as a kind of teaching. This lends colour to the idea that teaching goes beyond the field of the school, and that the teachers model described further above may have a wider application.

The important thing about the interpreters or transmitters of scientific information is that they must be trained, not as highly trained as research workers are, but nevertheless mostly university trained, which is to say they must have a good general grounding in science, they must understand and be able to explain, they must be able to learn and must have a keen interest.

It appears that broad intermediary strata of people trained in science and technology exist in the United States and they do on the whole not exist on the Continent of Europe. In Europe there is often a deep gap between the engineer and scientist with a seven to ten years' university training on the one hand, and technicians or non-graduate engineers who have insufficient theoretical background, and are often too thinly spread in numbers. This gap accounts for the relative isolation and ineffectiveness of scientists in these countries, which finds an expression in the stream of emigrants.

In my opinion the existence of broad and varied strata intermediary between the highly trained research worker and the technician is mainly responsible for the well-known ability of the Americans to use science for practical ends (whatever we may think of these ends and the way in which they are selected). People with training of various degrees permeate business and administration and the diffusion of new technical knowledge and methods is aided by this.

It would seem to follow that the technological gap could be narrowed at least in part by educational measures on the European Continent. The provision of intermediate degree courses (of about three years for engineers and scientists) which presumably would attract large numbers of students who are now discouraged by the excessive length and difficulty of technical and scientific studies, would in due course make the economy and the civil service more receptive to new ideas. The initiative for this lies almost wholly with the educational system which by appropriate reforms could actively influence the development of the economy.

6. It is generally agreed that assessing manpower requirements for purposes of educational planning is a very hard job, but what are the real reasons ? I find mainly two. The first, more obvious but less important, is that we often cannot gauge the effects of measures which we may consider taking, for example the benefit to the economy of an increased number of graduates. The second and more decisive reason is that we have in most cases no clear idea of the targets and aims of general economic policy to which our educational measures are to conform. This may not be equally true for all countries, but to a greater or lesser extent the difficulty exists everywhere.

On point one: I think that detailed studies relating to special fields might bring us a little further. For example, it should be possible to apply a cost-benefit analysis to Research and Development in industry. I think that in many big laboratories such analyses have been made, and that the material for them must, in principle, be available in many cases (whether it would be disclosed I cannot tell). The output of research, in the case of laboratories which have been existing for twenty years or more, can be seen in form of licenses, patents, prototypes, etc. The firms will be able to assess these things at a reasonable value. However speculative such estimates are, they will be better than equating the value of research activities to the wages paid to the scientists.

On point two: In dealing with manpower requirements we are trying to serve a master whose pleasures we do not know. We cannot work without aims and targets given to us by the lines of the country' s economic policy or its economic plan. In fact we require very clear and detailed indications of the standards of health service, the research policy, the manpower policy of administration and industry, etc. ; without such standards we are not able to reach any conclusions. But how far does this information carry us in practice ?

Take an example relating to medical doctors. The demand depends on the organisation or reorganisation of the hospital service, on the whole system of social security and health service of the country. These things may change considerably in the next ten years. It is known that far reaching reforms will probably take place, but nobody can tell what they will amount to. The influence of these questions on the demand for doctors is of extreme complexity, and it probably makes a great deal of difference. Yet we are left in the lurch completely by our master, the health service.

Another example relates to the demand for engineers and scientists according to field of study. It is known that the structure of industry is bound to change very much, and the direction of the change is known broadly (less production of basic materials). Nobody can tell, however, when and how quickly the changes will take place; and nobody can tell what goods are going to be produced to replace the output which has become unprofitable. We do not know either, therefore, in which direction the research ought to develop and how far it will be expanded. How should we know how to please the master, industry, by an appropriate education planning ?

Still another example. The demand for social scientists depends on the extent to which the public administration and the management of firms will employ them in preference to lawyers. On a sober estimate one can say that the employers have no idea what they will do five or ten years later (when, often, they will have been pensioned, anyway). Again, we have no way of pleasing our master, the public administration.

These examples may suffice to explain what I mean by saying that by far the greatest and foremost trouble in educational planning is that the people to whom we want to adapt do not know what they want from us and are not prepared for the simplest questions.

It would follow that the future development of educational planning will not consist in evolving magical formulae of forecasting, but rather in establishing links of information which ensure a permanent feed-back between education and other sectors.

7. Some people despair of manpower estimates simply because they expect too much of them. They are upset by the prospect of large errors in the forecasts. But this is not how we proceed in other fields. When shooting at a flying target we do not expect to hit at the first shot. (In fact, cybernetics has developed out of this problem). Also in the question of manpower we shall not be able to do anything better than firing shots repeatedly, and learning from the errors. An excess or deficiency in supply of say medical graduates over two or three years cannot be a major trouble, though it may be felt as an inconvenience. But, it will be objected, the teaching capacity has to be provided many years ahead, it is very costly and it cannot be changed afterwards. Yes, but it is known that capacity, space as well as personnel, is in practice elastic, just as it is in industry where demand cannot be forecast exactly either. The possibility of an error of 20% will therefore not make the forecasts useless.

The trial and error method of planning will proceed as follows: We estimate replacement requirements and compare them with the expected supply of skilled manpower. The difference will show the rate of growth of the stock of manpower. We have to judge then whether this is enough, or whether we shall need much more or much less. According to this we take corrective action e.g. provide new capacity. When this becomes effective we again make a new forecast of the prospective rate of growth.

This method clearly has limits. It will be more difficult to apply in a small country than in a large one where capacity can be increased in small steps.

Working by trial and error naturally leads back to the idea expressed at the end of the last paragraph. The function of manpower requirements analyses, as I understand it, is to provide a link between educational planning and the rest of the economy. This link has to be permanent and it must not be a one way street. Information must flow in both directions. There must be a feed-back of information from the economy (labour market) to the education authorities and back again.

I think that these channels of information and these feed-back arrangements will develop in a foreseeable future, and ultimately this will in great part be a consequence of the attempts at manpower analysis, for all its defects and failures, or perhaps just because of them.

APPENDIX

COUNTRY OBSERVATIONS AND ABBREVIATIONS

1 - For the Occupational Analysis

OECD COUNTRIES

Belgium	B
Canada	CDN
Denmark	DK
France	F
F.R. Germany	D
Great Britain	GB
Greece	GR
Ireland	IRL
Japan	J
Netherlands	NL
Norway	N
Portugal	P
Sweden	S
Turkey	TR
United States	USA

NON-OECD COUNTRIES

Argentina	RA
Chile	RCH
Costa Rica	CR
Ecuador	EC
Egypt	ET
El Salvador	ES
Finland	FL
Ghana	GH

NON-OECD COUNTRIES (Continued)

Honduras	HD
Hong Kong	HK
Hungary	H
Israel	IL
Jamaica	Jm
Korea (s)	KO
Mexico	MEX
Pakistan	PAK
Panama	PA
Peru	PE
Philippines	PI
Poland	PL
Puerto Rico	PR
Rumania	R
Sierra Leone	SL
South Africa	SA
Syria	SYR
Uruguay	U
USSR	USSR
Zambia	Z

2 - For the Occupational/Educational Analysis

OECD COUNTRIES

Canada	CDN
France	F
Greece	GR
Japan	J
Netherlands	NL
Norway	N
Portugal	P
Sweden	S
United States	USA

NON-OECD COUNTRIES

Argentina	RA
Chile	RCH
Ecuador	EC
Egypt	ET
Ghana	GH
Honduras	HD
Hungary	H
Israel	IL
Korea (s)	KO
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Syria	SYR
Uruguay	U
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